LONWORKS® Technology 101

A LONWORKS Platform Overview

LONMARK® AMERICAS

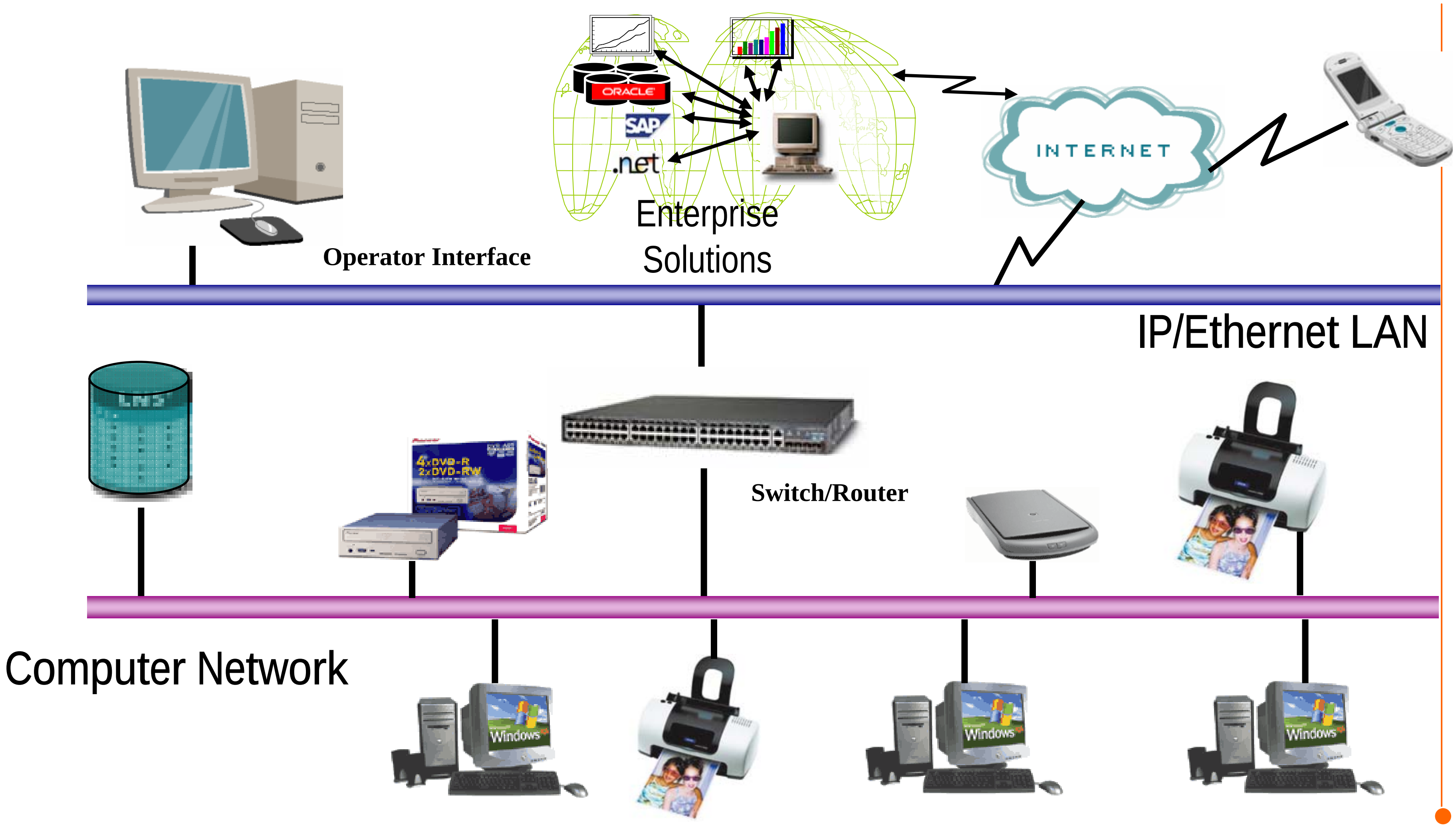
Agenda

- Welcome and Introductions
- LONWORKS Technology Background
- LONMARK® Technology Standards
- LONWORKS – LONMARK System Standards

Computer Network

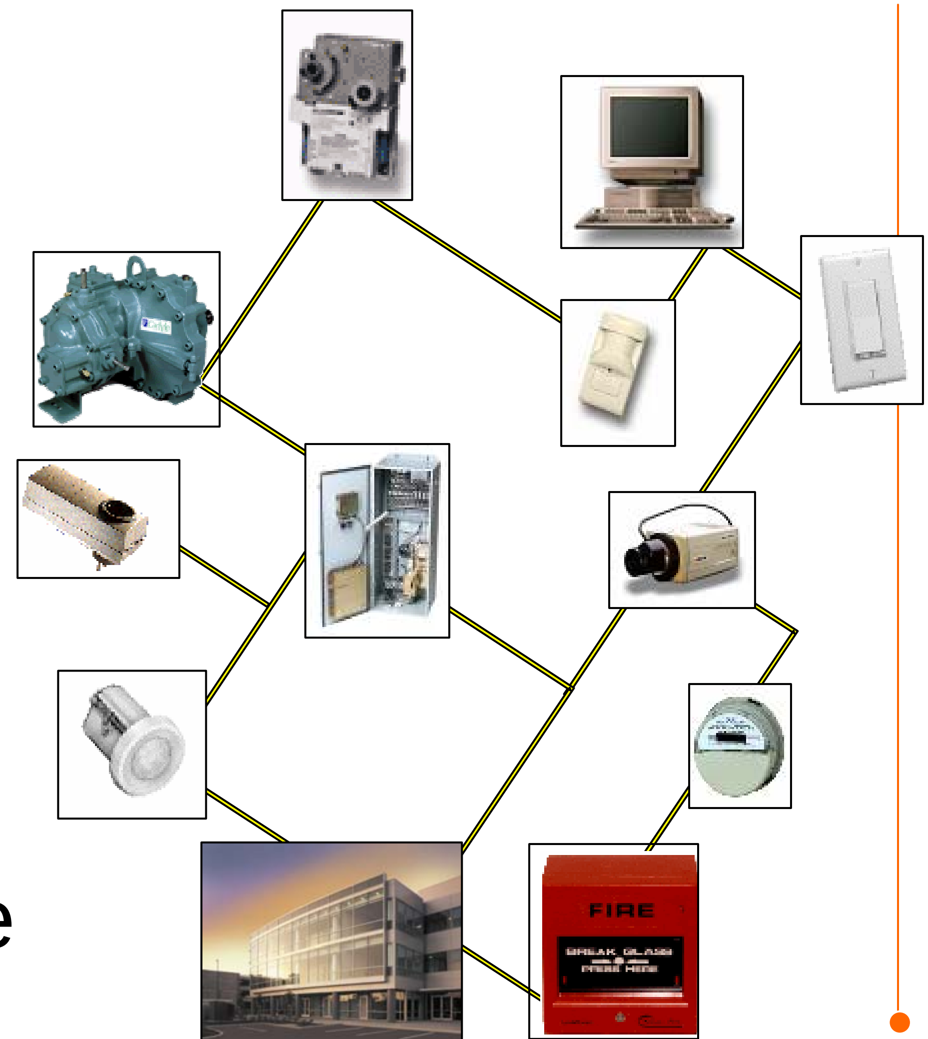
- Standardized
- Compatible products
- Interchangeable
- Interoperable
- Customizable
- Cost-efficient
- Multi-vendor
- Freedom of choice

Computer Network



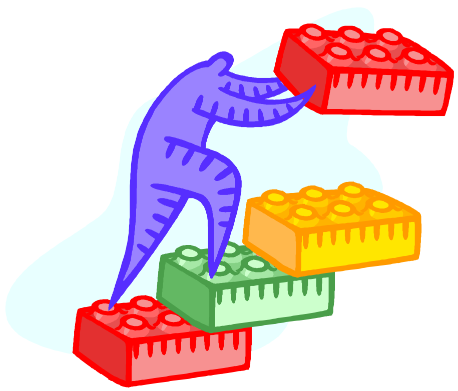
Device Network

- Standardized
- Compatible products
- Interchangeable
- Interoperable
- Customizable
- Cost-efficient
- Multi-vendor
- Freedom of choice



LonWorks Platform
Open System Building Blocks

Building an open system platform



- Design, and Installation Standards
- Network Infrastructure Standards
- HMI/Installation Standards

LonMark System Definition

- Standardized Device FB's
- Standardized System FB's

LonMark Functional Profiles

- Standard Data Types
- Standard Configuration Properties
- Function Blocks (FB)

LonMark Object Model

- Device data exchange
- Standard Network Management
- Network Variable Services

ANSI/EIA 709.1 Communications Protocol

ANSI/EIA/CEA-709.1 Protocol

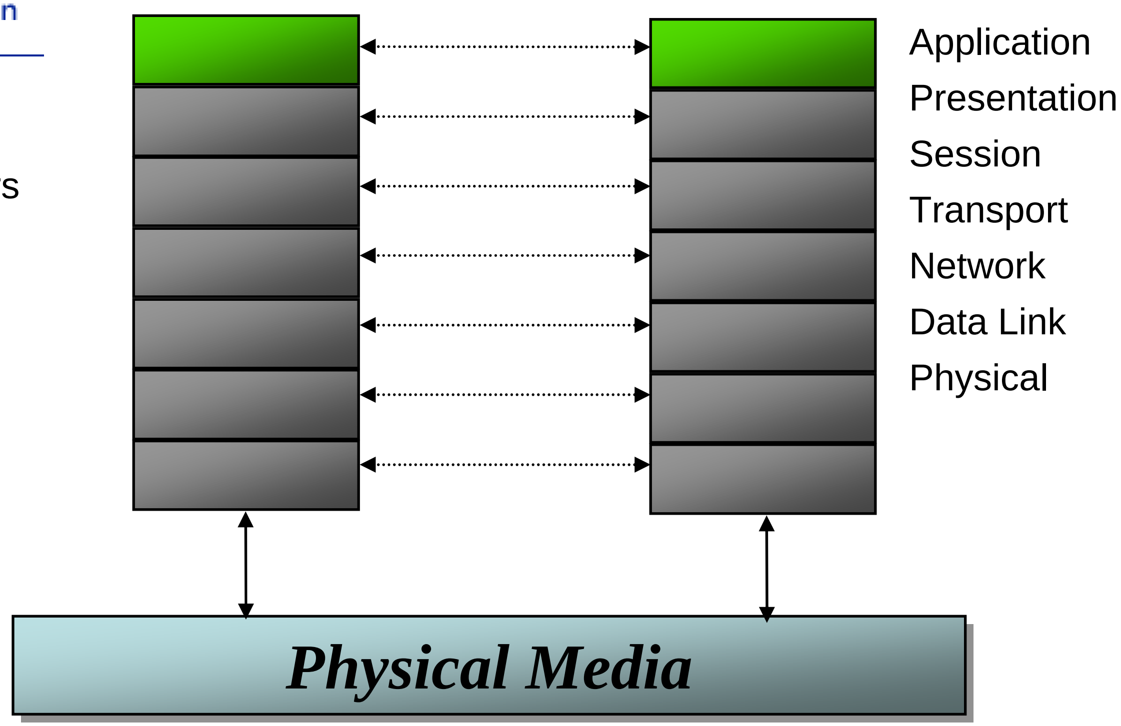
- An open standard protocol for control applications
  – Reference document available from Global Engineering

- Protocol implementations are available from multiple vendors
  – Protocol can be ported to any processor
  – Echelon's implementation is called the *LonTalk® protocol*
  – Echelon's Neuron® firmware includes the LonTalk protocol
  – Echelon development systems include a royalty-free unlimited license to use the Neuron firmware implementation

EIA-709.1 Protocol Layers

709.1 Implements the ISO standard – 7 Layers

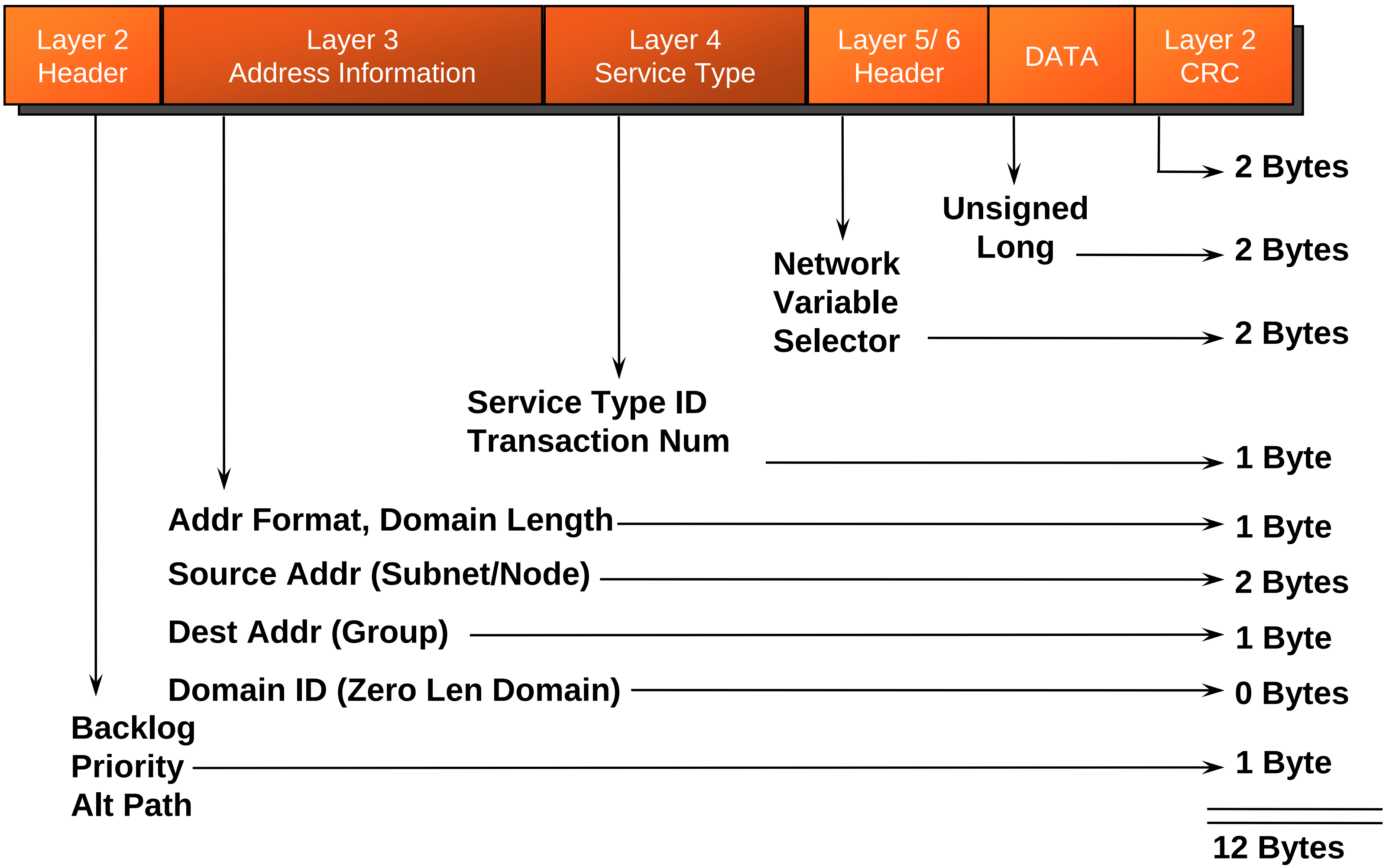
Many other control protocols implement only 3 or 4 layers



ANSI/EIA/CEA-709.1 Protocol Layers

	OSI Layer	*Purpose*	*Services Provided*
7	Application	**Application Compatibility**	**Network Configuration; Network Diagnostics; File Transfer; Application Configuration; Application Specification; Alarming; Data Logging; Scheduling**
6	Presentation	**Data Interpretation**	**Network Variables; Application Messages; Foreign Frame Transmission; Standard Types**
5	Session	**Control**	**Request-Response (NWM,Polling); Authentication**
4	Transport	**End-to-End Reliability**	**Acknowledged & Unacknowledged Message Delivery; Duplicate Detection**
3	Network	**Message Delivery**	**Unicast & Multicast Addressing; Routers**
2	Link	**Media Access and Framing**	**Framing; Data Encoding; CRC Error Checking; Predictive CSMA; Collision Avoidance; Priority & Collision Detection**
1	Physical	**Electrical Interconnect**	**Media-Specific Interfaces and Modulation Schemes (twisted pair, power line, radio frequency, coaxial cable, infrared, fiber optic)**

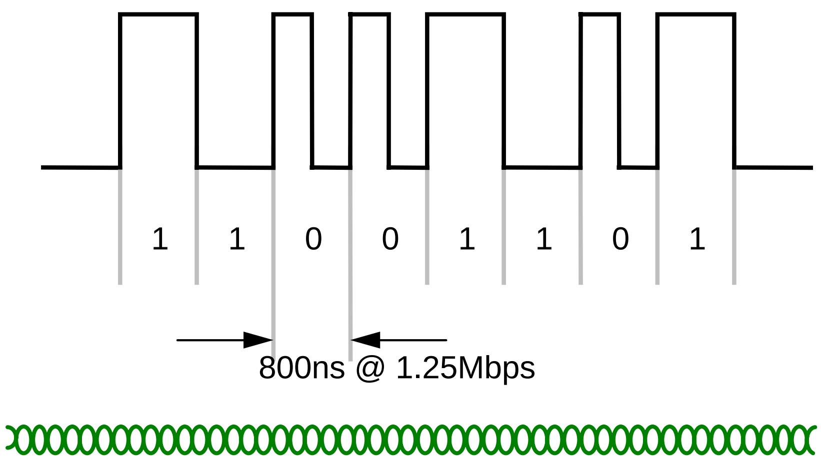
A Typical EIA-709.1 Packet



Layer 1—Physical Layer

Electrical interconnect

– Transmission of bits over a communication *channel (on the wire)*



LONMARK Channel Types

Name	*Media*	*Bit Rate*	*Definition*	*Standard*
FO-20L	Fiber Optic	1.25Mbps	ANSI/EIA/CEA-709.4	Yes
FO-20S	Fiber Optic	1.25Mbps	ANSI/EIA/CEA-709.4	Yes
IP-852	EIA/CEA-852 IP Tunneling	N/A	ANSI/EIA/CEA-852	Yes
PL-20A	CENELEC A-band Power Line	2613bps	ANSI/EIA/CEA-709.2	Yes
PL-20C	CENELEC C-band Power Line w/access protocol	3987bps	ANSI/EIA/CEA-709.2	Yes
PL-20N	CENELEC C-band Power Line w/o access protocol	3987bps	ANSI/EIA/CEA-709.2	Yes
TP/FT-10	Free Topology Twisted Pair	78.13kbps	ANSI/EIA/CEA-709.3	Yes
TP/RS485-39	RS-485 Twisted Pair	39.06kbps	EIA/TIA-232-E	Yes
TP/XF-1250	Transformer-Isolated Twisted Pair	1.25Mbps	LONMARK Interoperability Guidelines	Yes

LONMARK Channels Types
Some Common Standard Channels

IP-852 Channel

~ 35,000 PPS on 10baseT(10 Mbit)
scales with channel (100/1000 Mbit)
Supports aggregation

IP Backbone
(Switched 100Mbit,Gigabit Ethernet)

TP/XF-1250 Channel

1.25 Mbps

~ 720 Peak / 576 Sustained PPS

FT-10 Channel

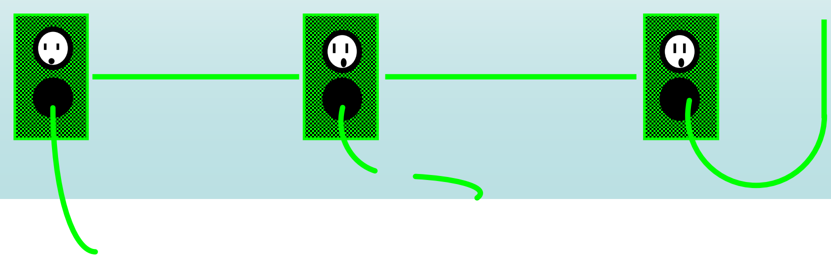
78 Kbps

~ 220 Peak / 180 Sustained PPS

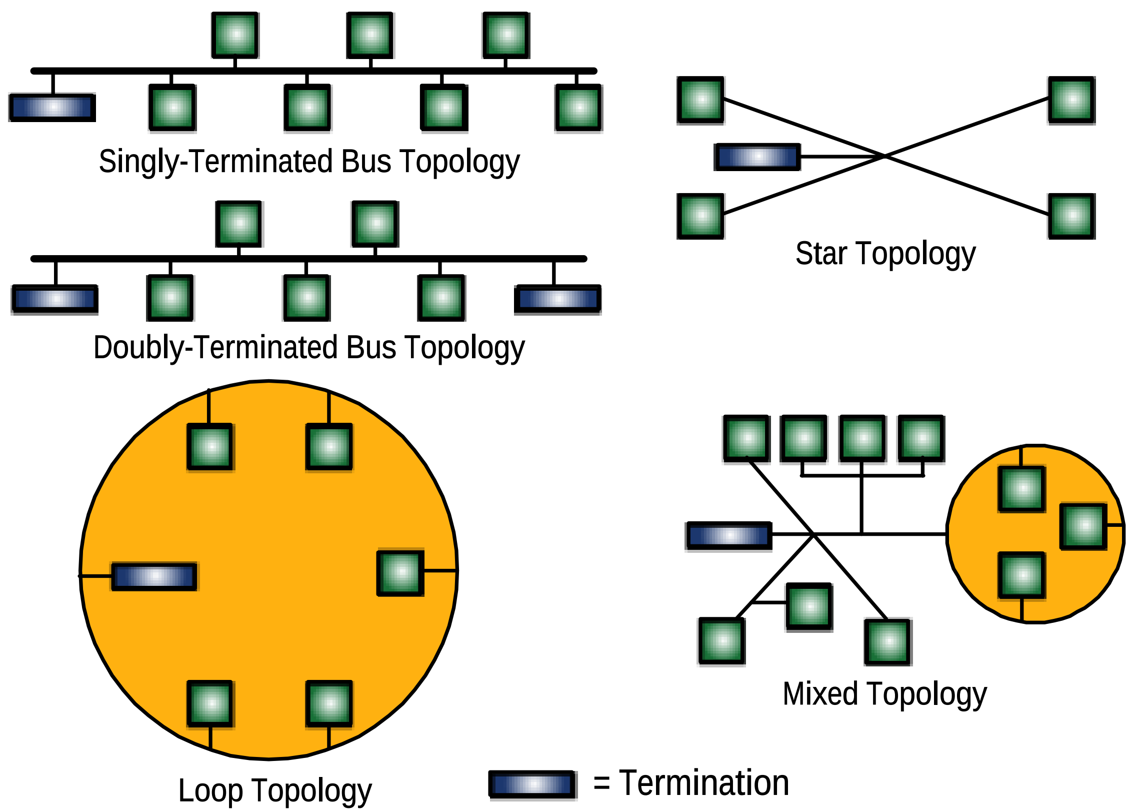
5 Kbps

PL-20 Channel

~ 20 PPS



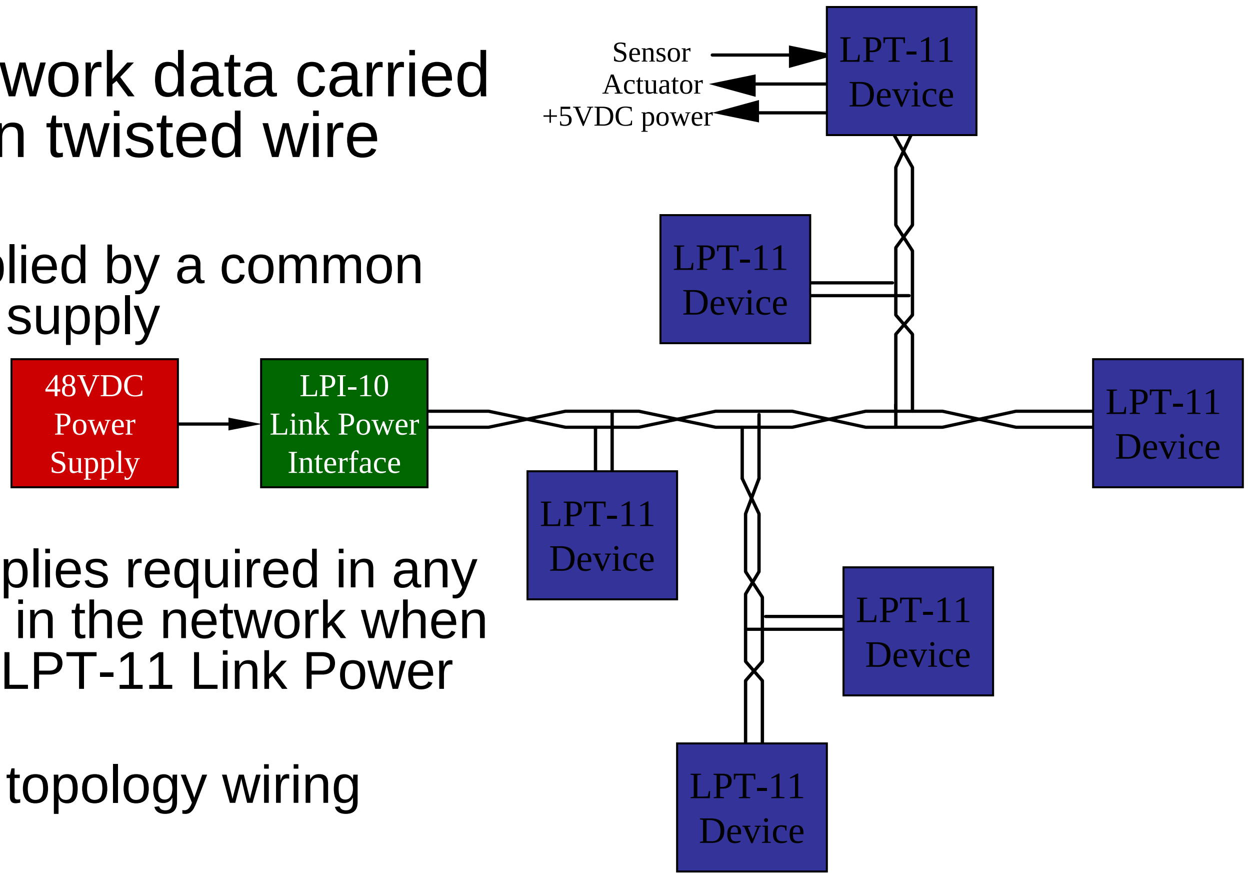
ANSI/EIA/CEA 709.3-A TP/FT-10 Channel



- Unshielded & Shielded Twisted pair
  - Level IV, CAT 5, 24AWG ,16AWG
  - Polarity insensitive wiring
- 64 (128 linked power) devices on a single channel segment

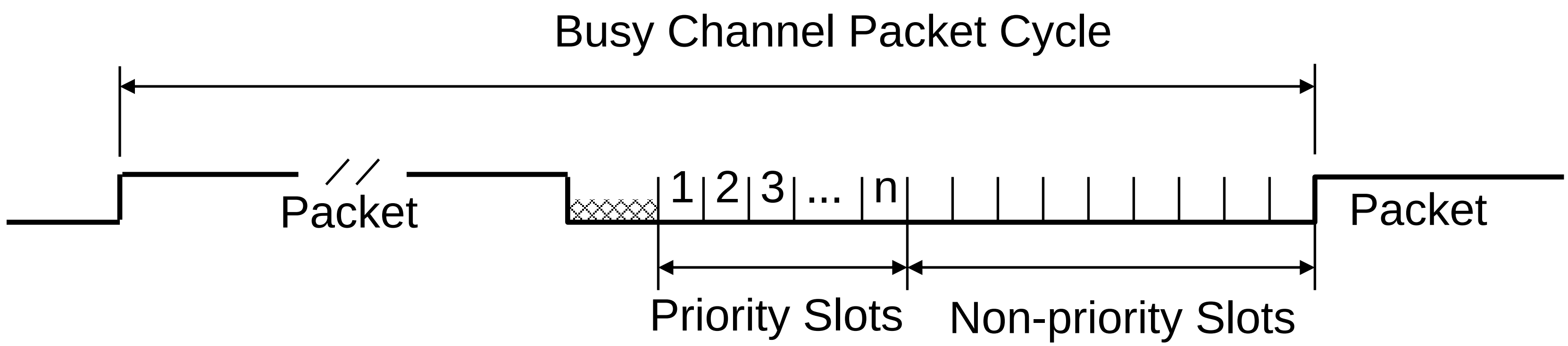
Physical Layer—TP/FT-10 Link Power

- Power and network data carried over a common twisted wire pair
  - Power is supplied by a common central power supply



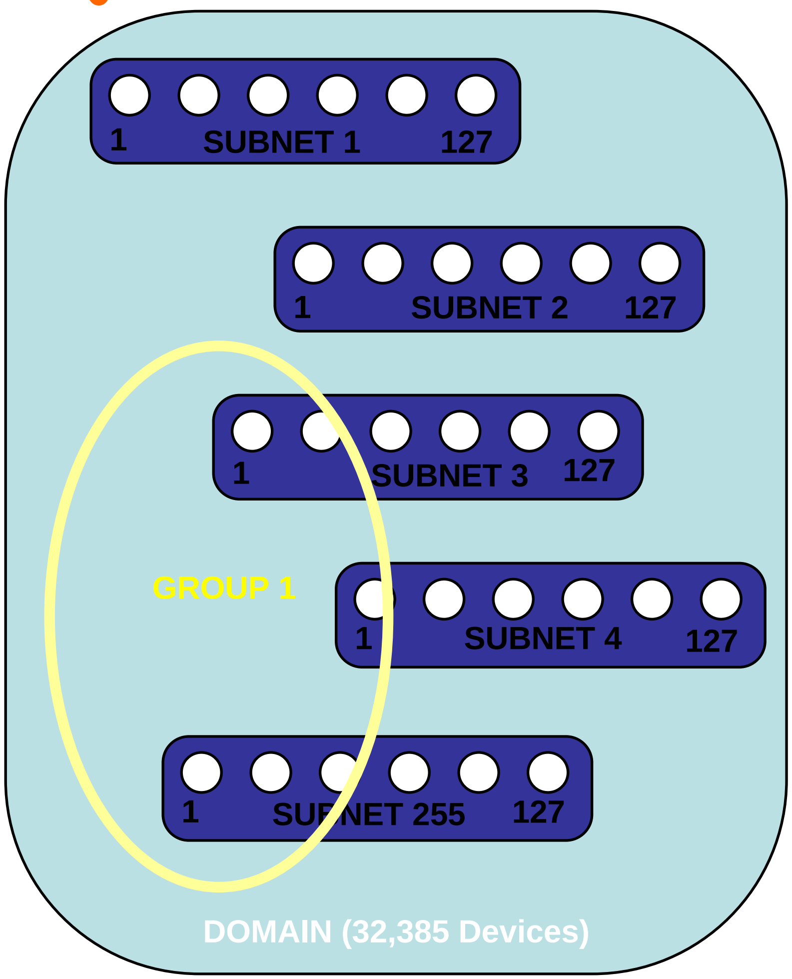
  - No power supplies required in any of the devices in the network when used with the LPT-11 Link Power Transceiver
  - Supports free topology wiring architecture

Link Layer—Media Access Priority



- Configurable priority messages
  - Reserved time slot
  - Reduces overall channel bandwidth
- Priority slot number is assigned at installation time
- No collisions possible during priority portion of packet cycle following preceding packet
- Highest priority message has predictable response time

Layer 3—Network Layer



- Message delivery
  – How data frames are routed from a source device to one or more destination devices
- Physical address
  – 48-bit Neuron ID—used for initial configuration
- Logical addresses
  – **Domain** Identifies subsystem on open media or large system
  – **Subnet** Subset of a domain typically

Network Layer Addressing Modes

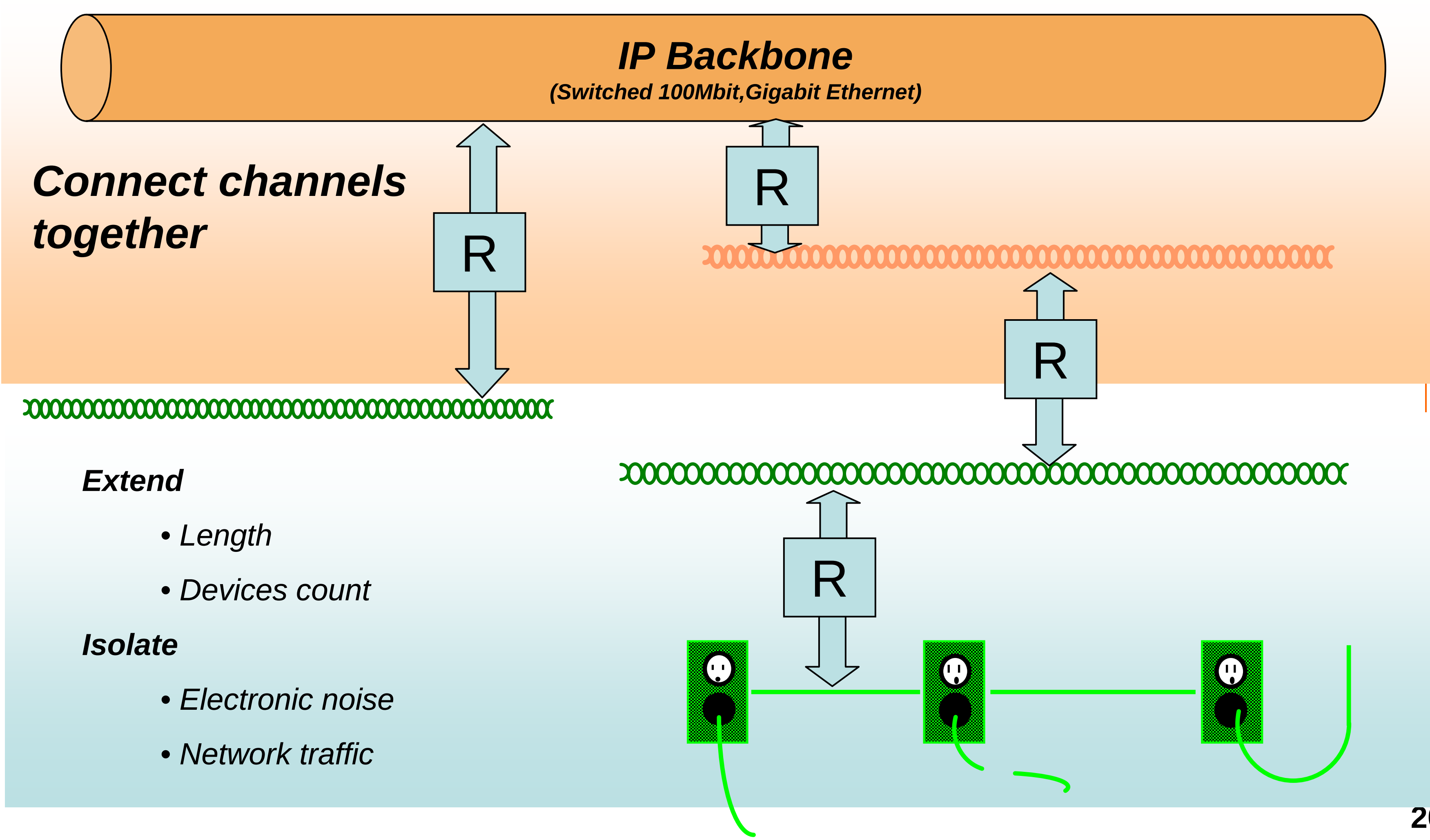
Address Mode	*Address Format*	*Destination*	*Address Size (bytes)*
Domain-wide Broadcast	**Domain (Subnet = 0)**	**All devices in the domain**	3
Subnet-wide Broadcast	**Domain, Subnet**	**All devices in the subnet**	3
Unicast	**Domain, Subnet, Node**	**Specific device within a subnet**	4
Multicast	**Domain, Group**	**All devices in the group**	3
Neuron ID	**Domain, Neuron-ID**	**Specific device**	9

- Optimize bandwidth with multiple addressing modes
- Application communications only requires 3- or 4-byte network addresses
- Send messages to many devices using only a single 3-byte network address

Network Layer Capacity

- 18,446,744,073,726,329,086 domains
- 255 subnets per domain
- 127 devices per subnet
- 32,385 devices per domain
- 256 groups per domain
- 64 devices per acknowledged group
- 32,385 devices per unacknowledged group

LonMark 709.1 Network Routers



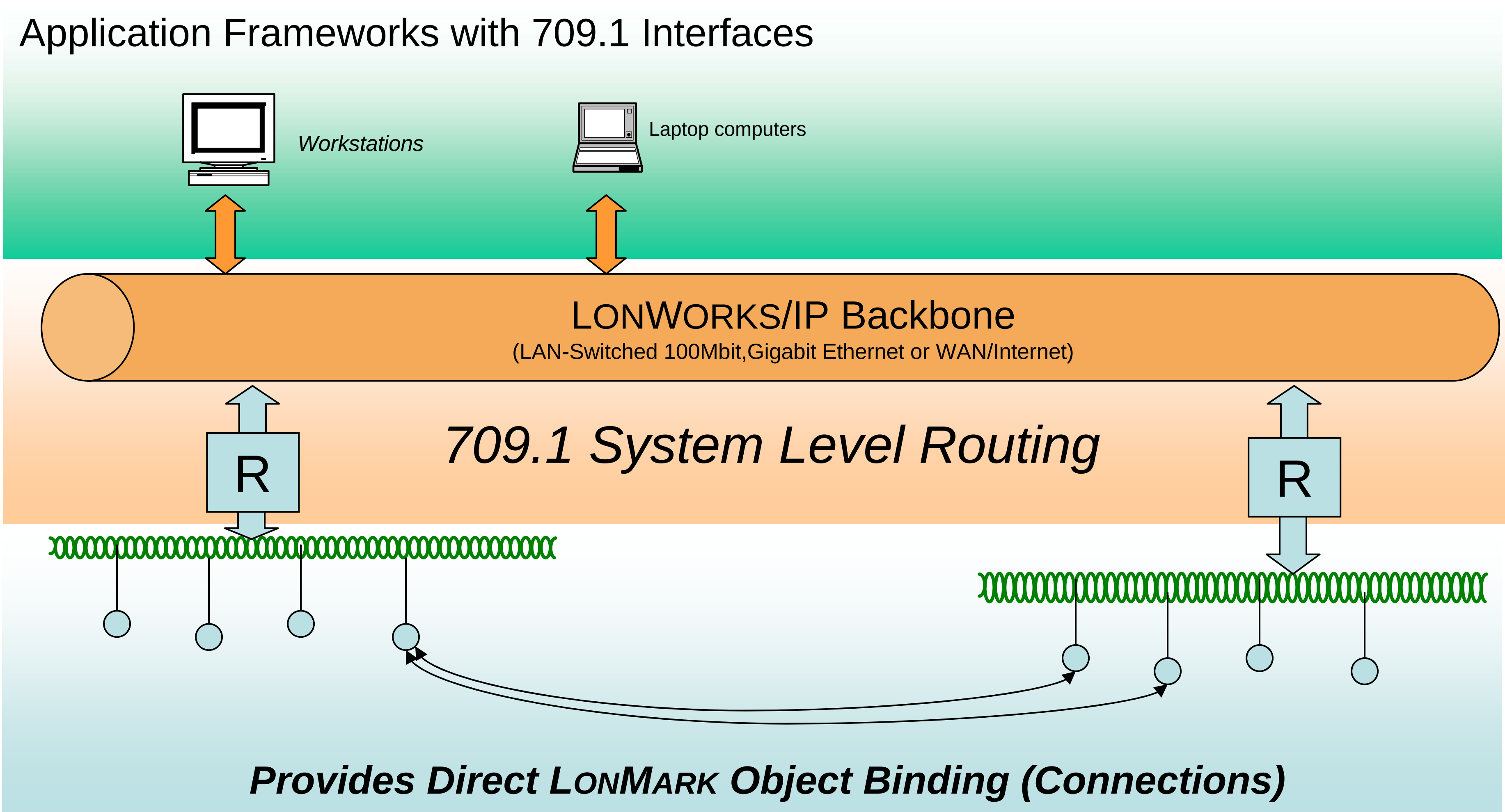
Extend

- *Length*
- *Devices count*

Isolate

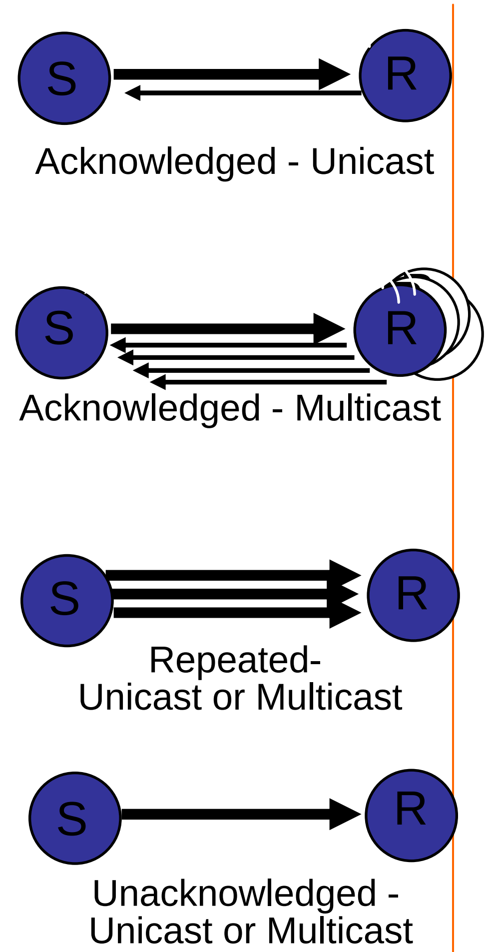
- *Electronic noise*
- *Network traffic*

LONMARK 709.1 Network Routers

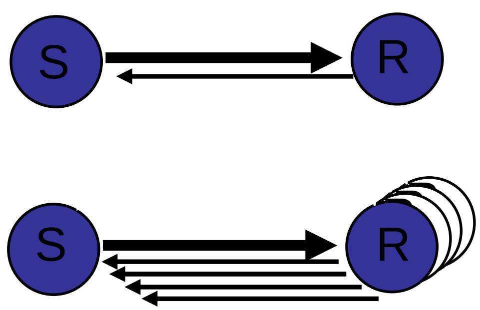


Layer 4 - Transport Layer

- Provides reliable delivery of message packets
- Three message delivery services
  - **Acknowledged**
    - Sending device requires acknowledgment from all receiving devices
    - All acknowledgments are end-to-end
    - Automatic retries if acknowledgement not received
  - **Repeated**
    - Configurable number of messages per transaction
    - Conserves bandwidth with large groups
    - Better response time
    - Three repeats provides > 99.999% probability of delivery
  - **Unacknowledged**
    - One message per transaction
    - Conserves network bandwidth and provides highest performance
- Duplicate detection prevents repeated messages to the application

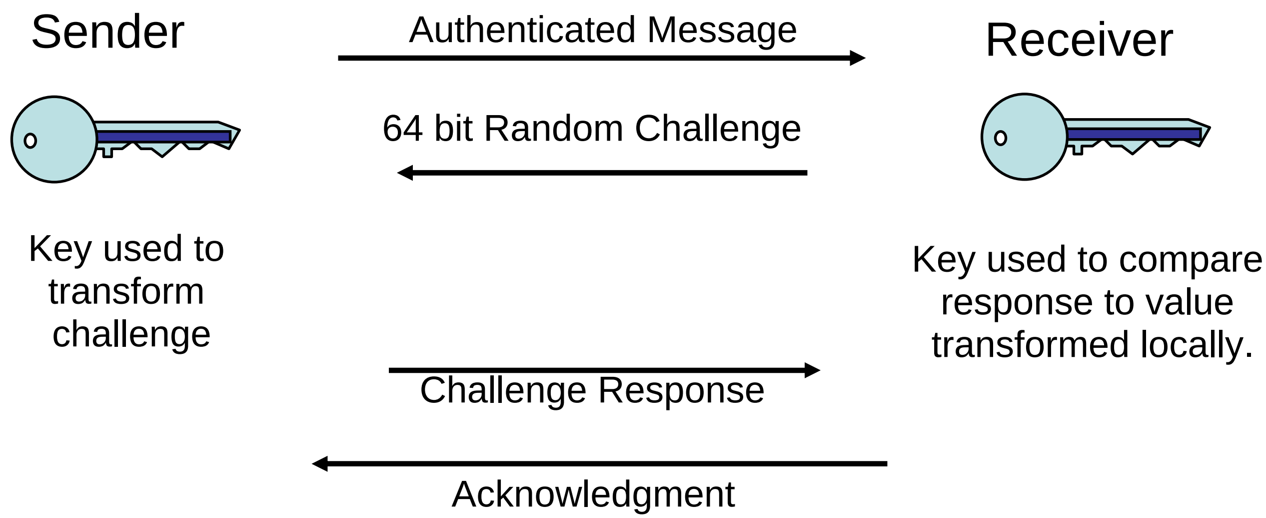


Layer 5 - Session Layer



- Adds control to the data exchanged by the lower layers
- Request/response service
  - Used for device management, fetching values, and requesting other remote actions
- Authentication
  - Verifies identity of message sender…

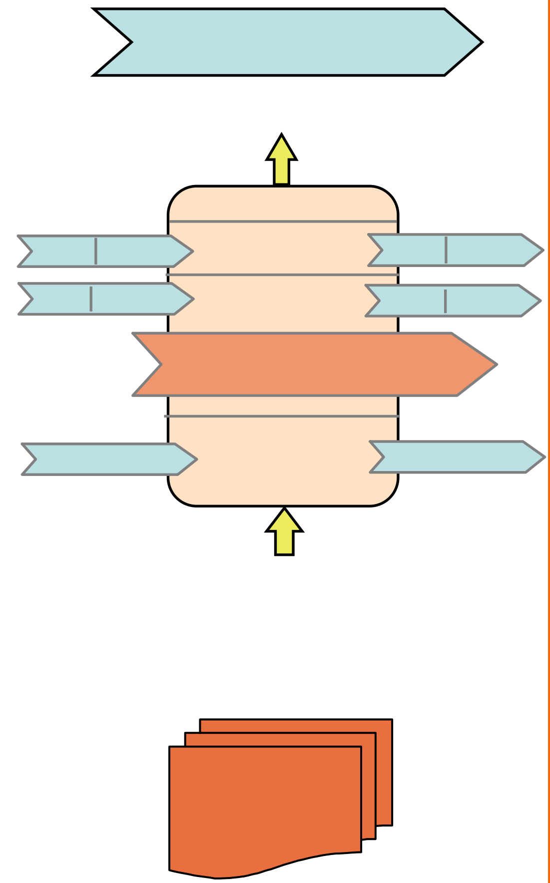
Session Layer Authentication



- Verifies identity of message sender
- Uses a 48-bit secret key known by each device
- Sender must provide correct reply to 64-bit random challenge from the receiver

Interoperability Guidelines

- Data interpretation
  - Standard representation of data types
- Standardized functional behavior of a nodes
  - LONMARK objects
  - encapsulated network interaction of defined functions
- Standardized support of smooth and trouble free installation
  - Self documentation of a network oriented external interface
  - Guidelines for Network Management

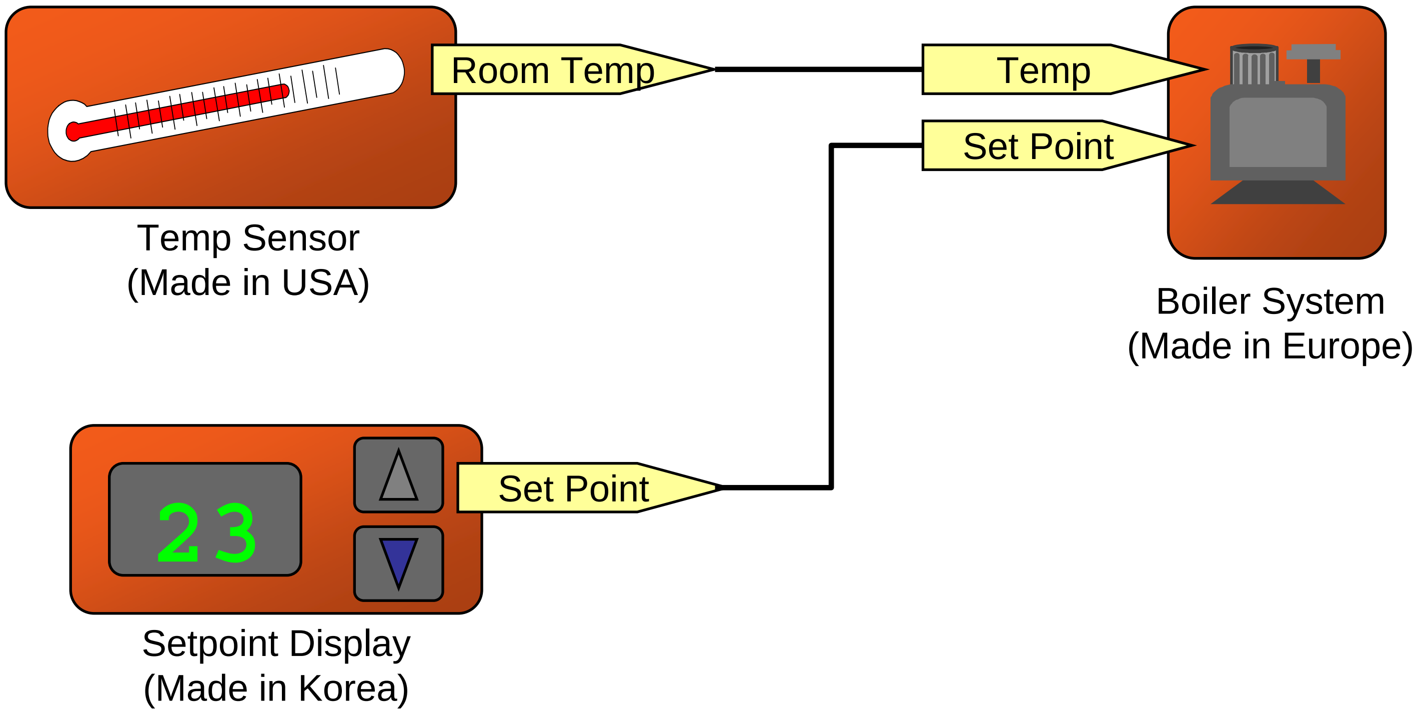


Standard Network Variable Types Are The Core Of Interoperability

SNVT_temp	Temperature	Degrees Celsius	-274..6271	0.1 degree
SNVT_angle	Phase/Rotation	Radians	0 - 65	0.001 rads
SNVT_speed	Speed	Meters/Sec	0 - 6553	0.1 m/s
SNVT_elapsed_tm	Elapsed Time	HH:MM:SS	0 - 65535 days	1 msec
SNVT_lev_cont	Continuous Level	Percent	0 - 100%	0.5%
SNVT_ascii	ASCII String	Characters	30 Chars	N/A
SNVT_count	Events	Count	0 - 65535	1 Count

Ref: SNVT Master List und Programmer's Guide

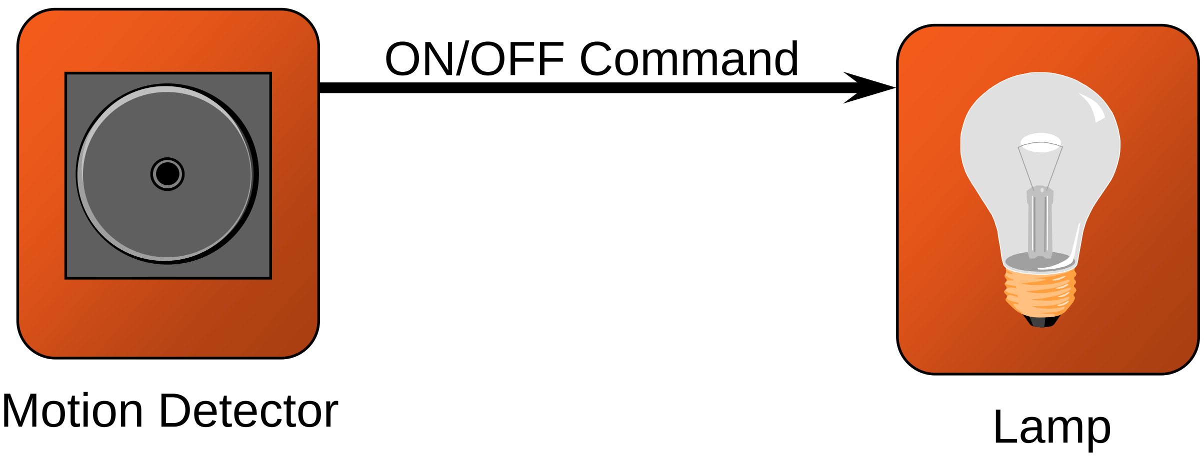
Layer 6 - Presentation Layer



- Data exchanged using *network variables*
  - Propagation automatically handled by Neuron firmware
  - Provides fastest and most compact code
- Devices from different manufacturers can exchange data with a common interpretation

Presentation Layer—Command-Based Systems

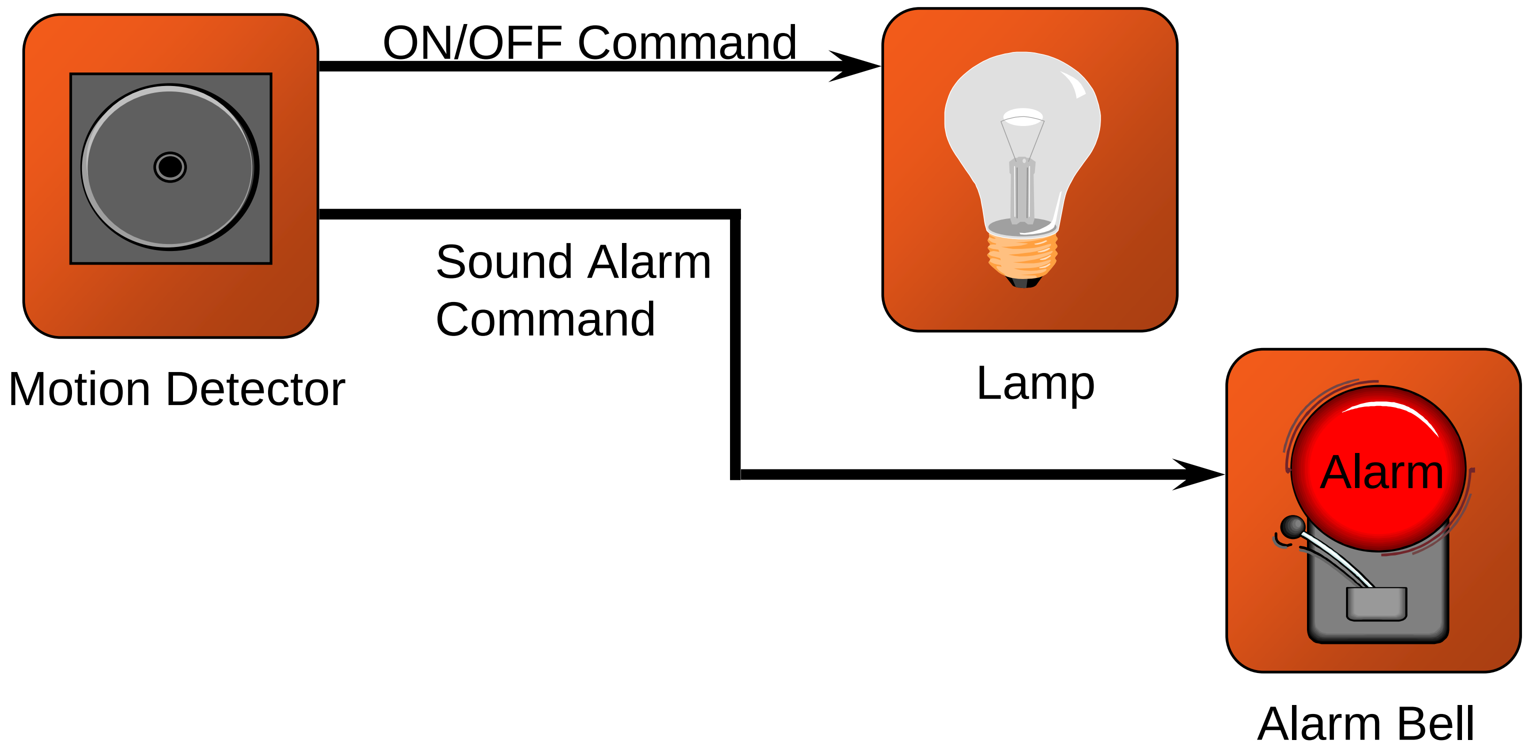
The old way…



- **The decision to turn the lamp ON or OFF is made in the motion detector.**
- **This system applies a master/slave approach to control. The master (motion detector) commands everything in the system.**

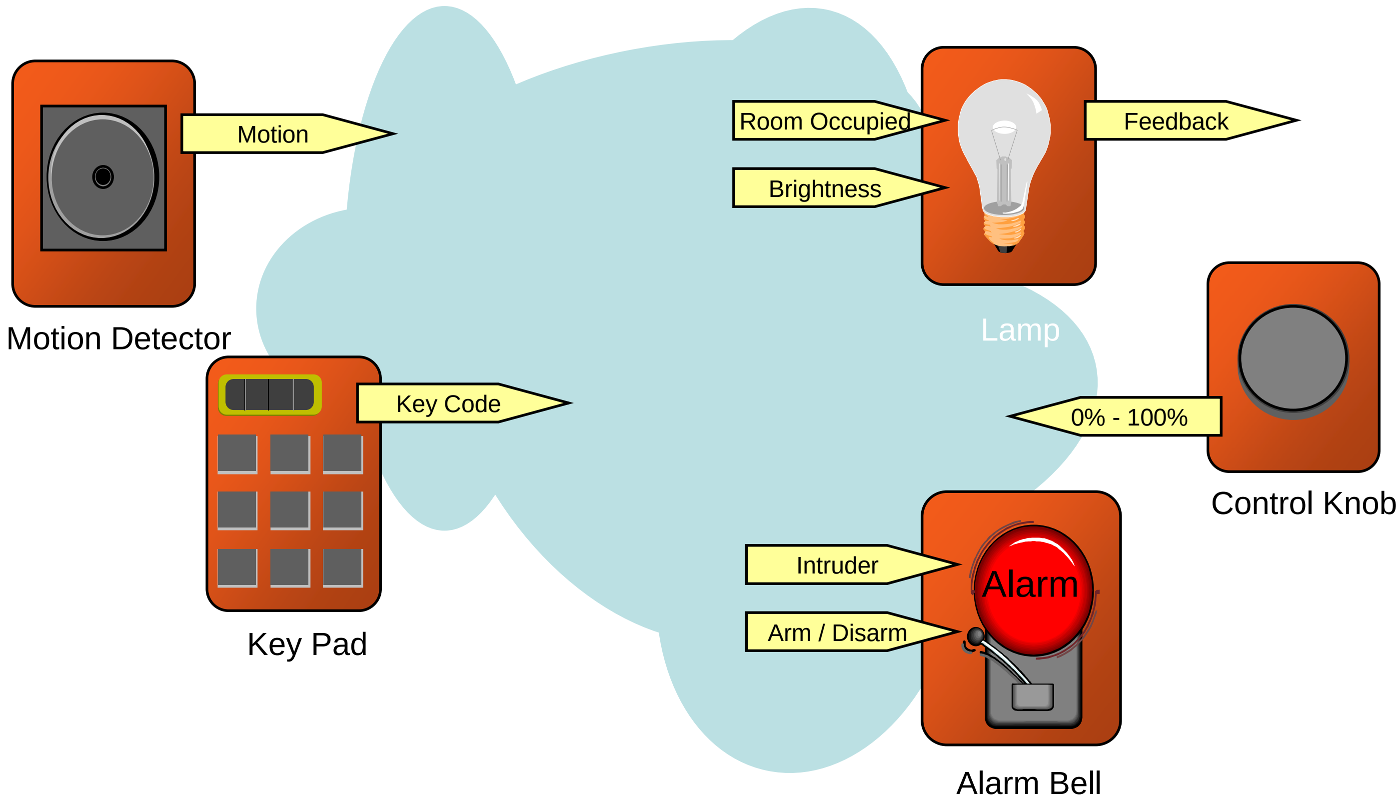
Presentation Layer—Adding a Device

Using the old way, additions are difficult…



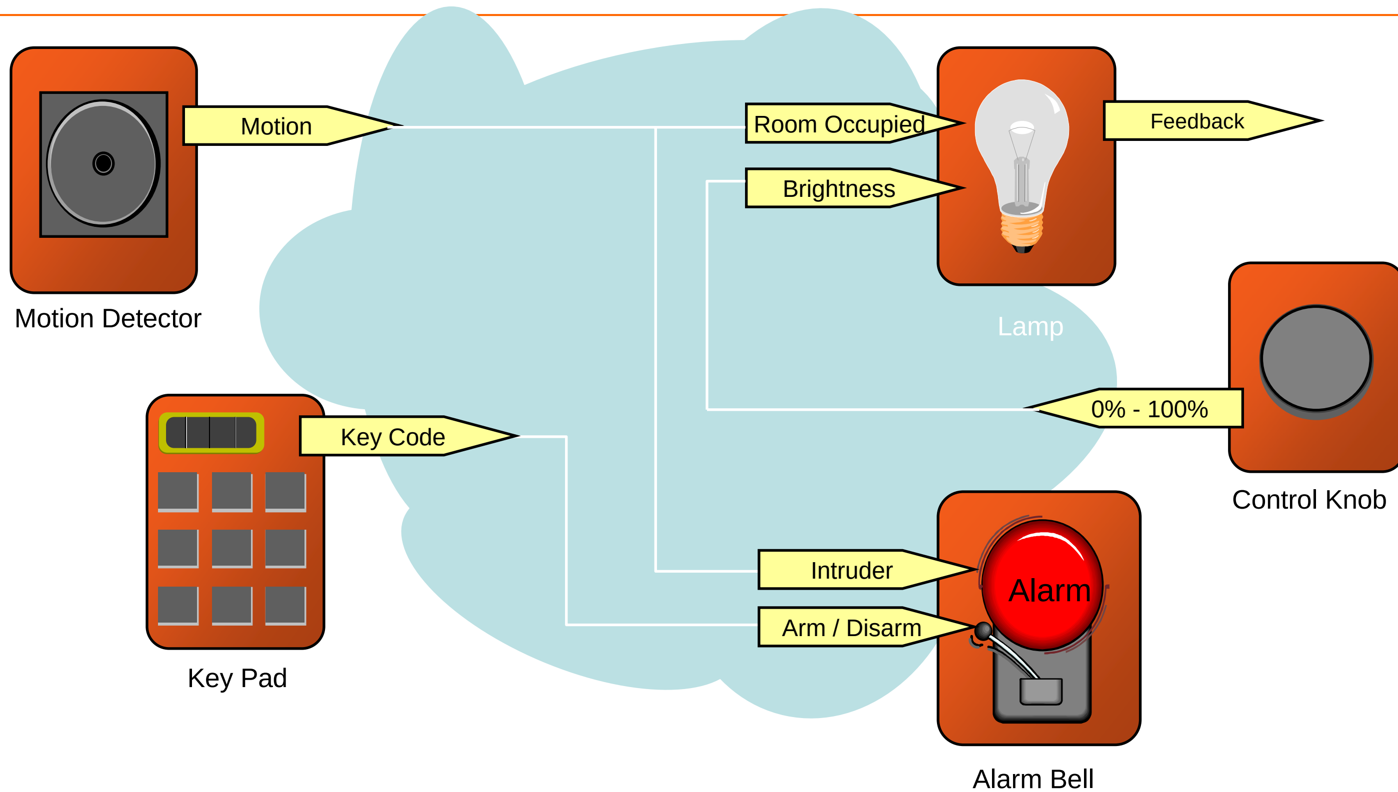
- Adding a new device (the Alarm Bell) requires a software change in the motion detector so it can send commands to the alarm bell and the light

Presentation Layer—Using Network Variables



- Sensors “publish” information, and actuators “subscribe” to the information of interest to them!

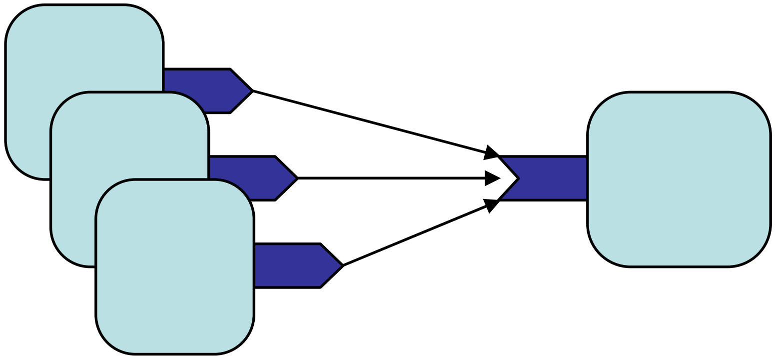
Presentation Layer—Adding Devices



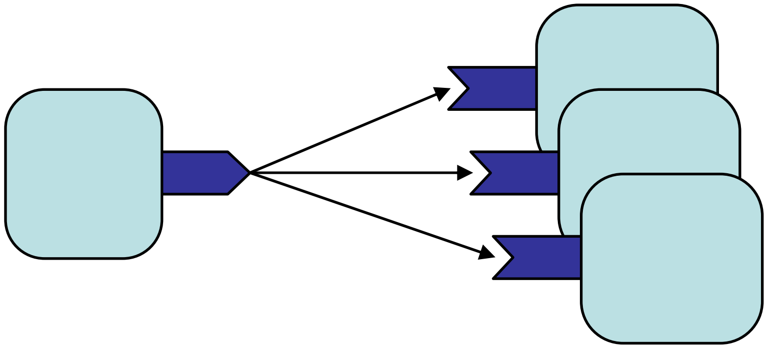
- Devices are logically connected (“bound”) together without affecting the application program in the device!

Presentation Layer—Fan In/Out

- Devices may have many network variables
- Many network variables may *fan-in* to one network variable



- Many network variables may *fan-out* from one network variable



Presentation Layer
Standard Network Variable Types

- SNVT_speed
- SNVT_speed_f
- SNVT_speed_mil
- SNVT_state
- SNVT_state_64
- SNVT_str_asc
- SNVT_str_int
- SNVT_switch
- SNVT_telcom
- SNVT_temp
- SNVT_temp_diff_p
- SNVT_temp_f
- SNVT_temp_p
- SNVT_temp_ror
- SNVT_temp_setpt
- SNVT_therm_mode
- SNVT_time_f
- SNVT_time_hour
- SNVT_time_min
- SNVT_time_passed
- SNVT_time_sec
- SNVT_time_stamp
- SNVT_time_zone
- SNVT_tod_event
- SNVT_trans_table

SNVT_temp_p

Overview:

Temperature (degrees Celsius) .

Details:

Standard:	*yes*
Resource Set:	*Standard 00:00:00:00:00:00:00:00-0*
Index:	*105*
Obsolete:	*no*
Size:	*2*
Programmatic Name:	*SNVT_temp_p*
Neuron C Type:	signed long

Minimum:	*-27317*
Maximum:	*32767*
Invalid:	*32767*
Scaling (A,B,C):	*1, -2, 0*
Scaled value:	$1 * 10^{-2} * (Raw+0)$
Resolution:	*0.01*

Presentation Layer—Standard Formatting

- Standard formatting for standard types ensures consistent data presentation in tools and HMIs
- Example
  - A **SNVT_temp_p** value of 2940 is displayed as follows:

Formats:

*SNVT_temp_p#SI: text("%f", *1+0(0:854))*

*SNVT_temp_p#US: text("%f", *1.8+32(0:855))*

*SNVT_temp_p#US_diff: text("%f", *1.8+0(0:855))*

29.4 degrees C

84.9 degrees F

52.9 degrees F

Application Layer Configuration Properties

- SCPTmaxSupplyFanCapacity
- SCPTminDefrostTime
- SCPTminDeltaAngl
- SCPTminDeltaCO2
- SCPTminDeltaFlow
- SCPTminDeltaLevel
- SCPTminDeltaRH
- SCPTminDeltaTemp
- SCPTminDischargeAirCoolingSetpoint
- SCPTminDischargeAirHeatingSetpoint
- SCPTminDuctStaticPressureSetpoint
- SCPTminFlow
- SCPTminFlowHeat
- SCPTminFlowHeatStby
- SCPTminFlowSetpoint
- SCPTminFlowStby
- SCPTminFlowUnit
- SCPTminFlowUnitHeat
- SCPTminFlowUnitStby
- SCPTminOutdoorAirFlowSetpoint
- SCPTminPressureSetpoint
- SCPTminRemoteFlowSetpoint
- SCPTminRemotePressureSetpoint
- SCPTminRemoteTempSetpoint
- SCPTminReturnExhaustFanCapacity
- SCPTminRnge
- SCPTminSendTime
- SCPTminSetpoint
- SCPTminSndT
- SCPTminStroke
- SCPTminSupplyFanCapacity
- SCPTmixedAirLowLimitSetpoint

SCPTminSendTime

Overview:

Minimum send time. The minimum period of time between consecutive transmissions of the current value

Details:

Standard:	*yes*
Resource Set:	*Standard 00:00:00:00:00:00:00-0*
Index:	*52*
Obsolete:	*no*
Size:	*2*
Programmatic Name:	*SCPTminSendTime*
Default:	*0.0*
Neuron C Type:	*SNVT_time_sec*

Application Layer Configuration Properties

Configuration properties (CP's) characterize the behavior of a device in the system.

- Standard Configuration Property Types (SCPT's) define data encoding types.lonmark.org
- Manufacture specific CP's defined by LONMARK format resource files.
- Used for device configuration/options
  (e.g. VAV /w reheat, RTU /w 2 stage heat)
- Common system level configuration property types
  - SCPTminSendTime (throttle)
  - SCPTmaxSendTime (heartbeat)

Application Layer—Network Configuration and Diagnostics

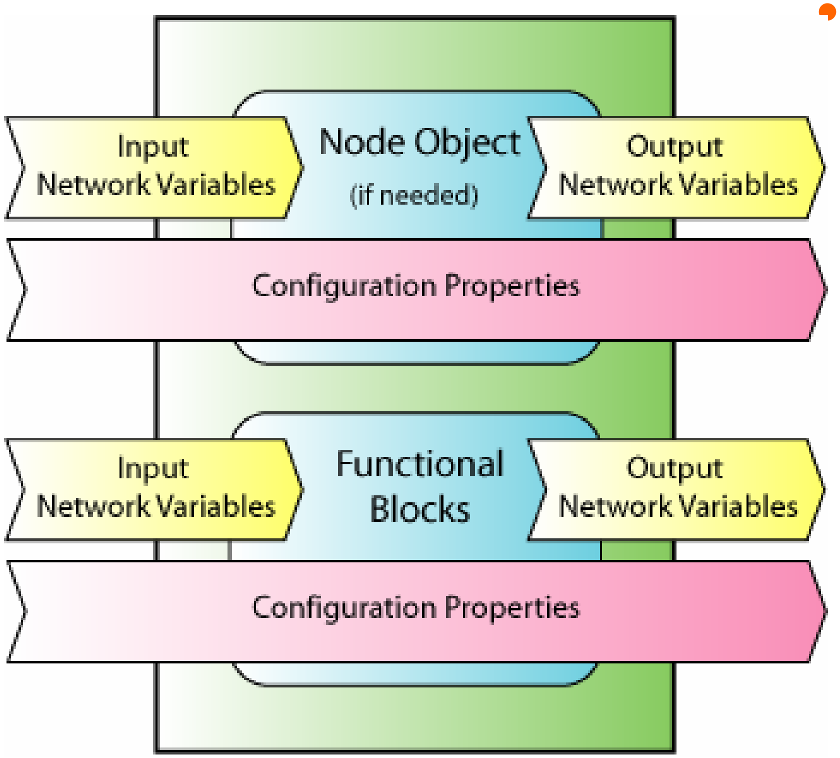
Network Management and Diagnostic Messages	
Query Status Proxy Command Clear Status Query Transceiver Status Query ID Respond to Query Update Domain Leave Domain Update Key Update Address Query Address Query Net Variable Config	Update Group Address Data Query Domain Update Net Variable Config Set Node Mode Read Memory Write Memory Checksum Recalculate Wink Memory Refresh Query SNVT Network Variable Fetch Device Escape Code

- Common standard foundation for network installation and diagnostic tools

Layer 7—Application Layer

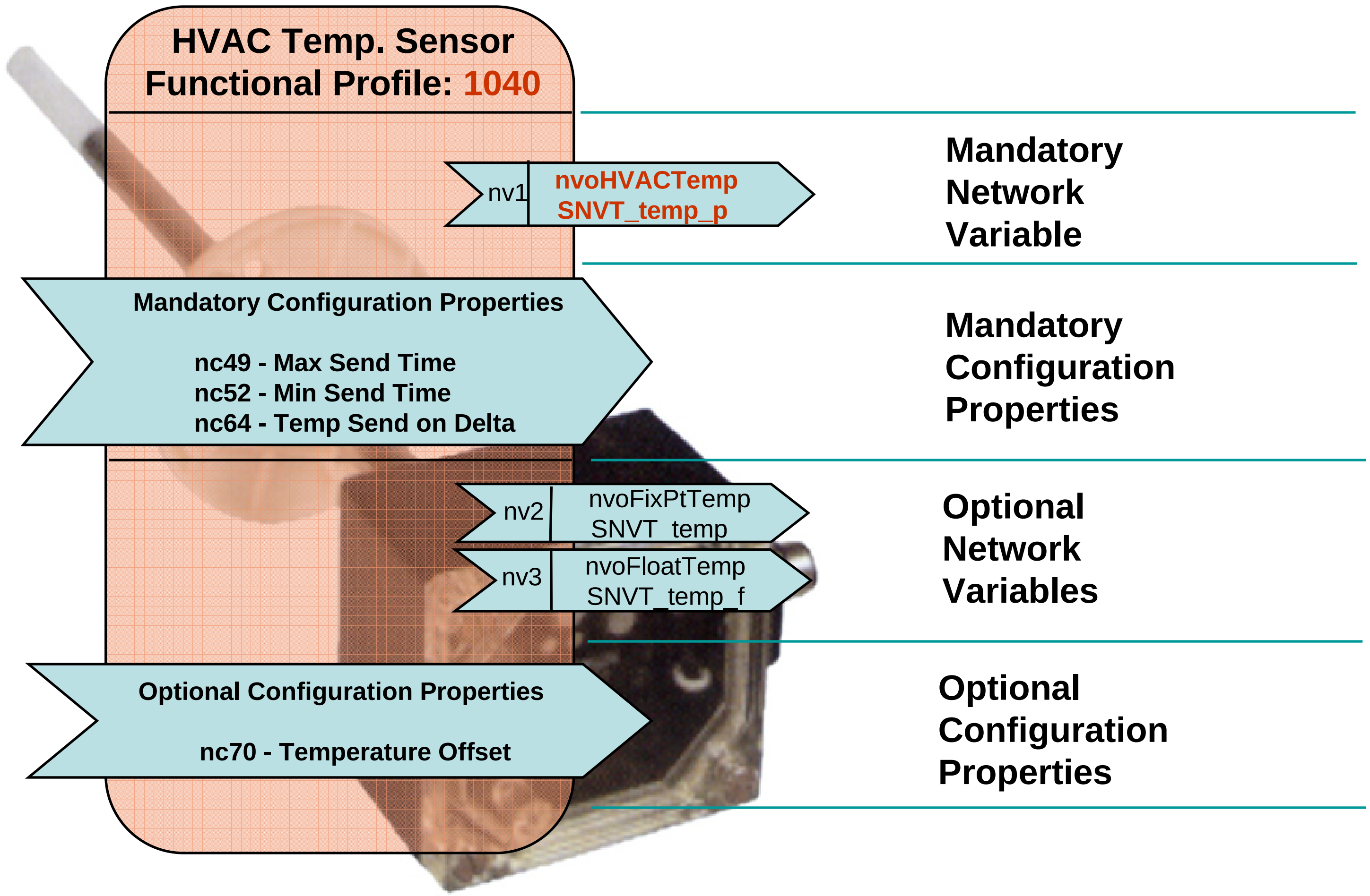
- Defines standard network services that use data exchanged by the lower layers
  - Network configuration
  - Network diagnostics
  - File transfer
  - Application configuration
  - Application specification
  - Alarming
  - Data logging
  - Scheduling

Application Layer—Application Specification

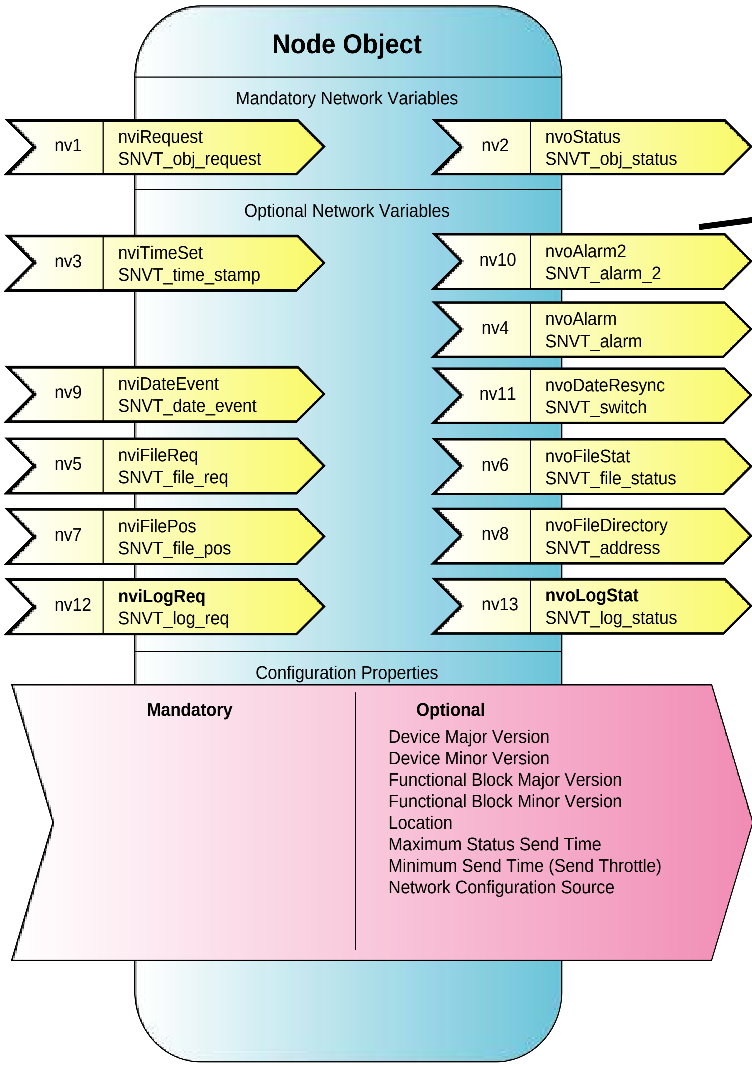


- Functional block
  - Portion of a device's application that performs a task
  - Receives configuration and operational data inputs
  - Processes the data
  - Sends operational data outputs

Functional Profile: HVAC Temperature Sensor

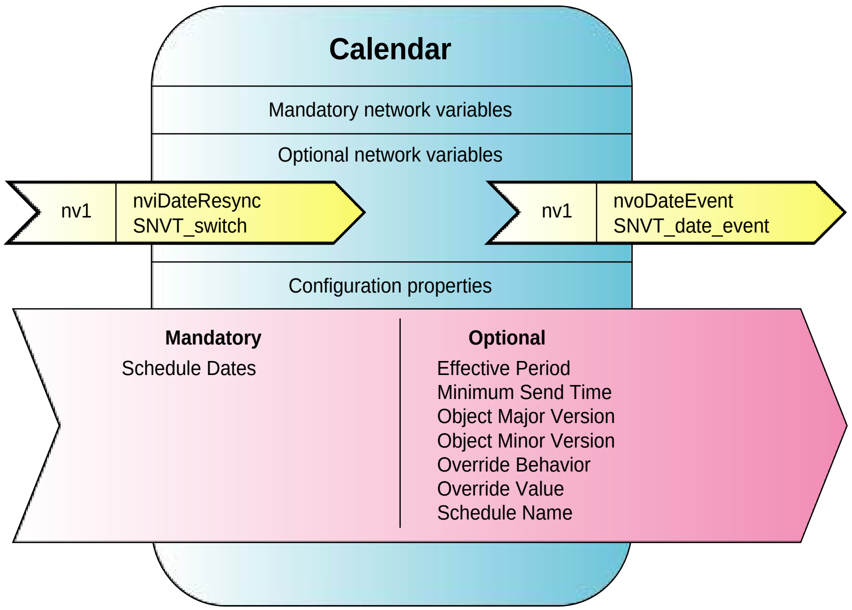


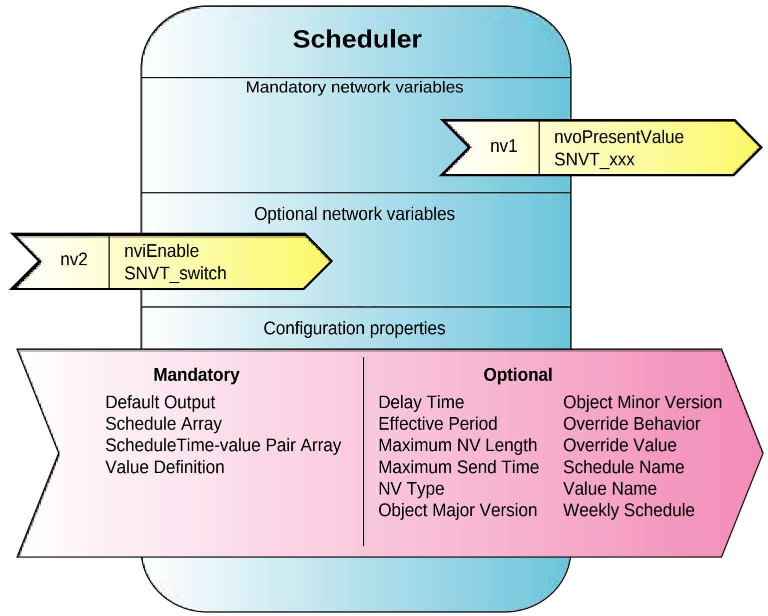
Application Layer—Alarming



- Standard alarm reporting output, includes:
  - Alarm type
  - Alarm priority
  - Alarm time
  - Sequence number
  - Alarm description
- Ensures consistent reporting of alarm events

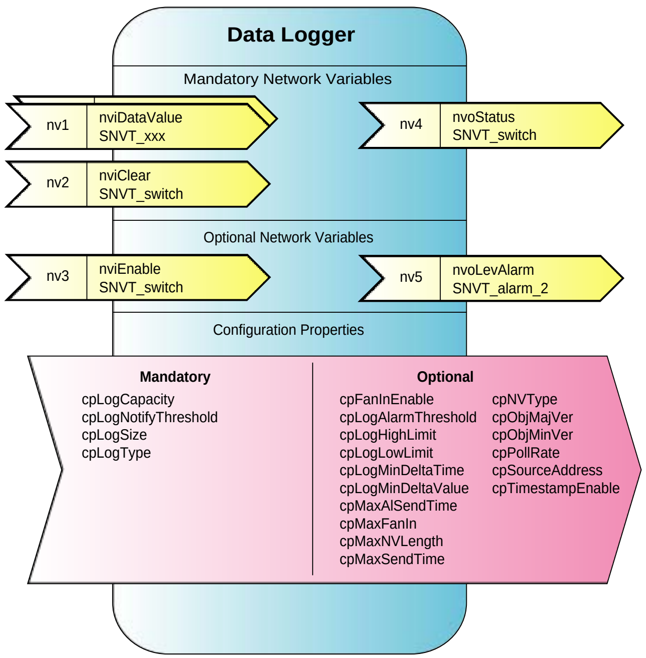
Application Layer—Scheduling

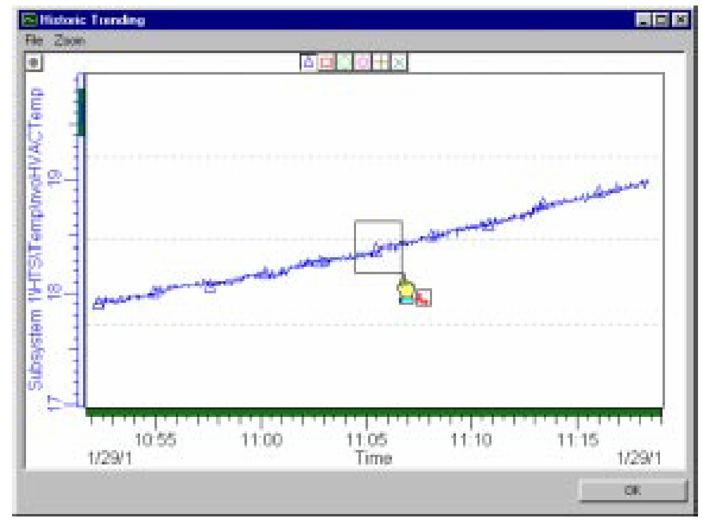




- Standard profile for identifying events based on date and time
- Supports scheduling applications that work with scheduling devices from multiple manufacturers

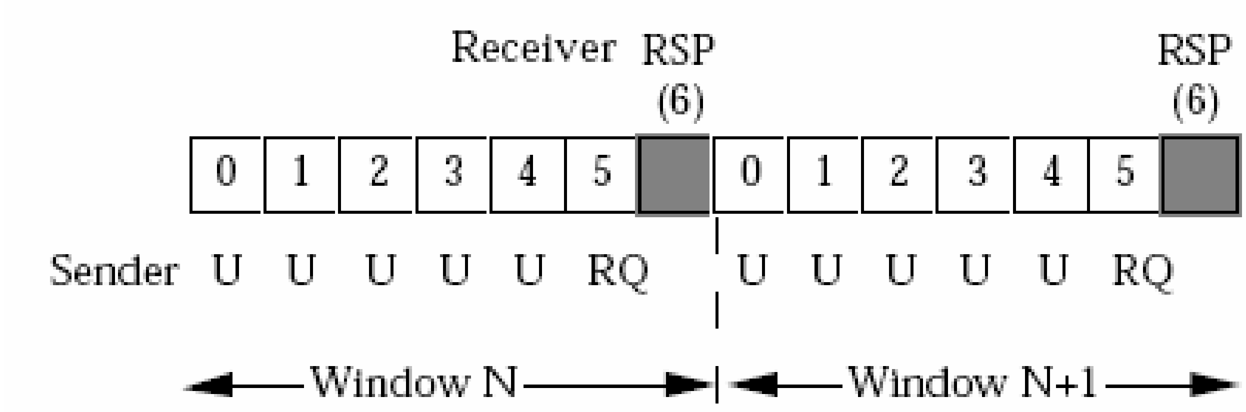
Application Layer—Data Logging





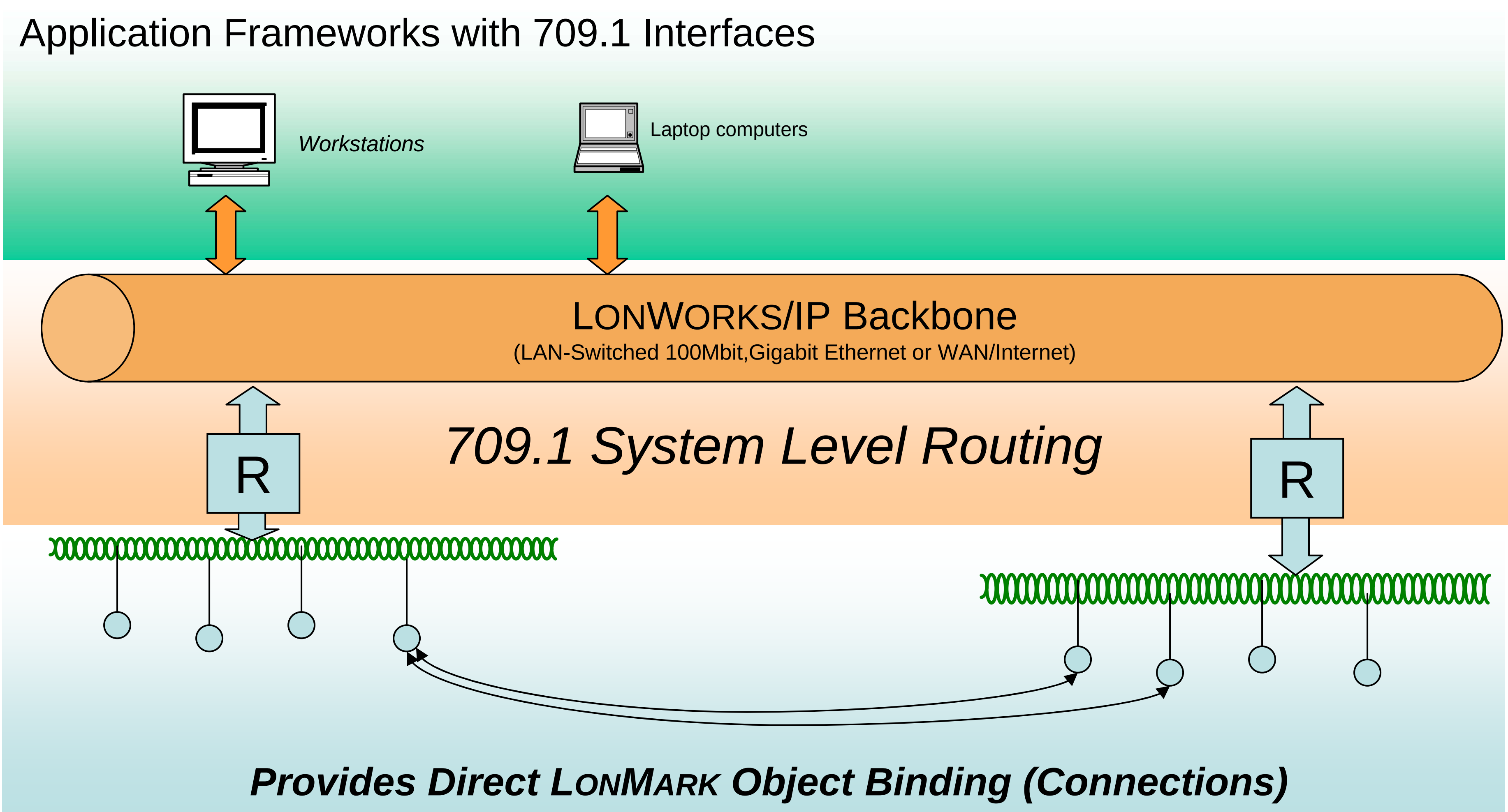
- Standard profile for collecting data in a log
  - Currently if final review by the LONMARK BAS Task Group
- Collect data locally
- Archive data remotely
- View data locally or remotely

Application Layer
File Transfer Protocol

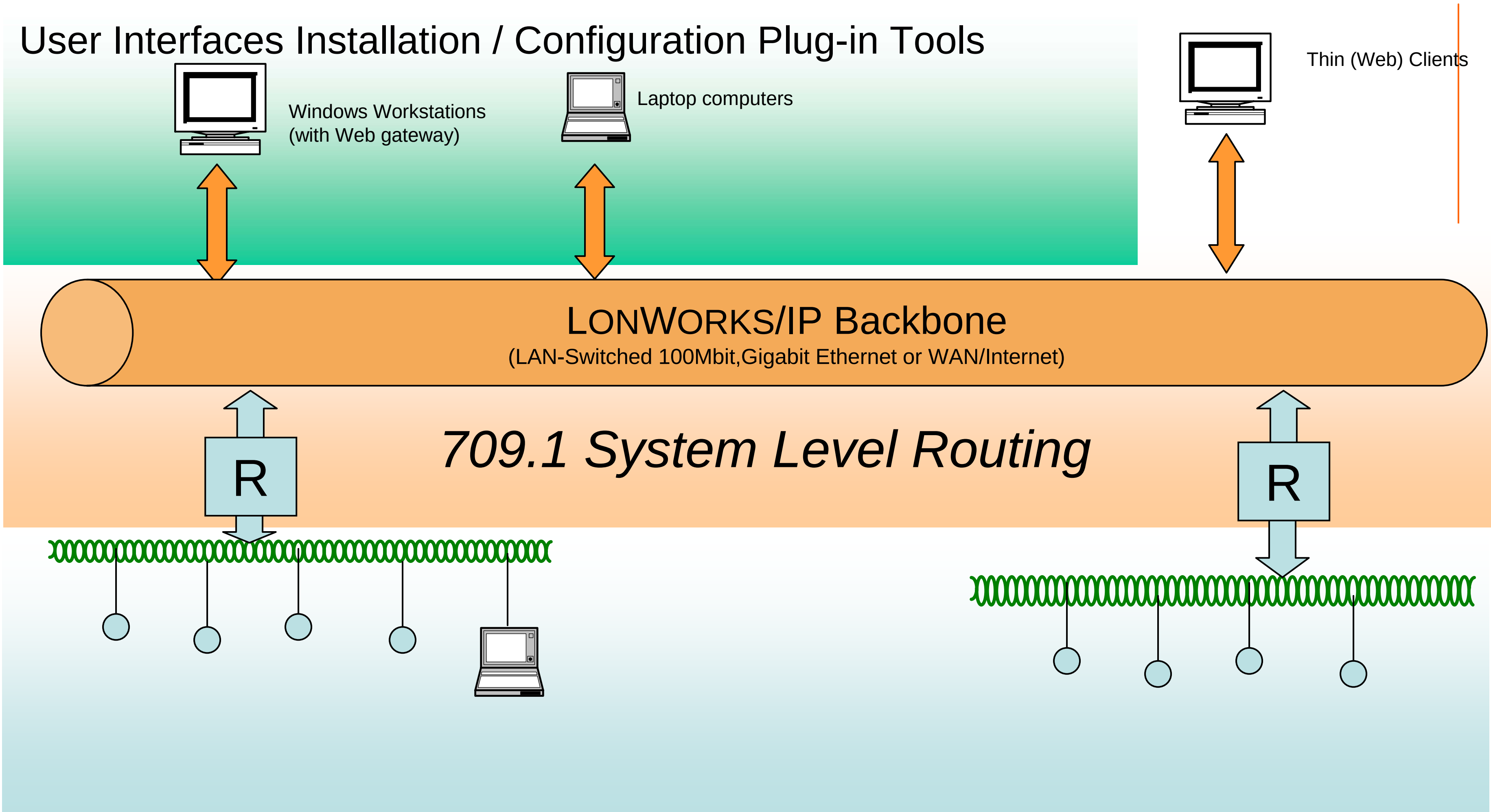


- Standard service for transferring large blocks of data
- Data stream sent in six packet *data windows*
  - Five unacknowledged application message packets
  - Followed by one request/response application message packet
- Avoids overhead of acknowledging every packet
  - 85% of packets contain data; only 15% overhead for acknowledgements
  - Allows recovery from a lost packet within six packets

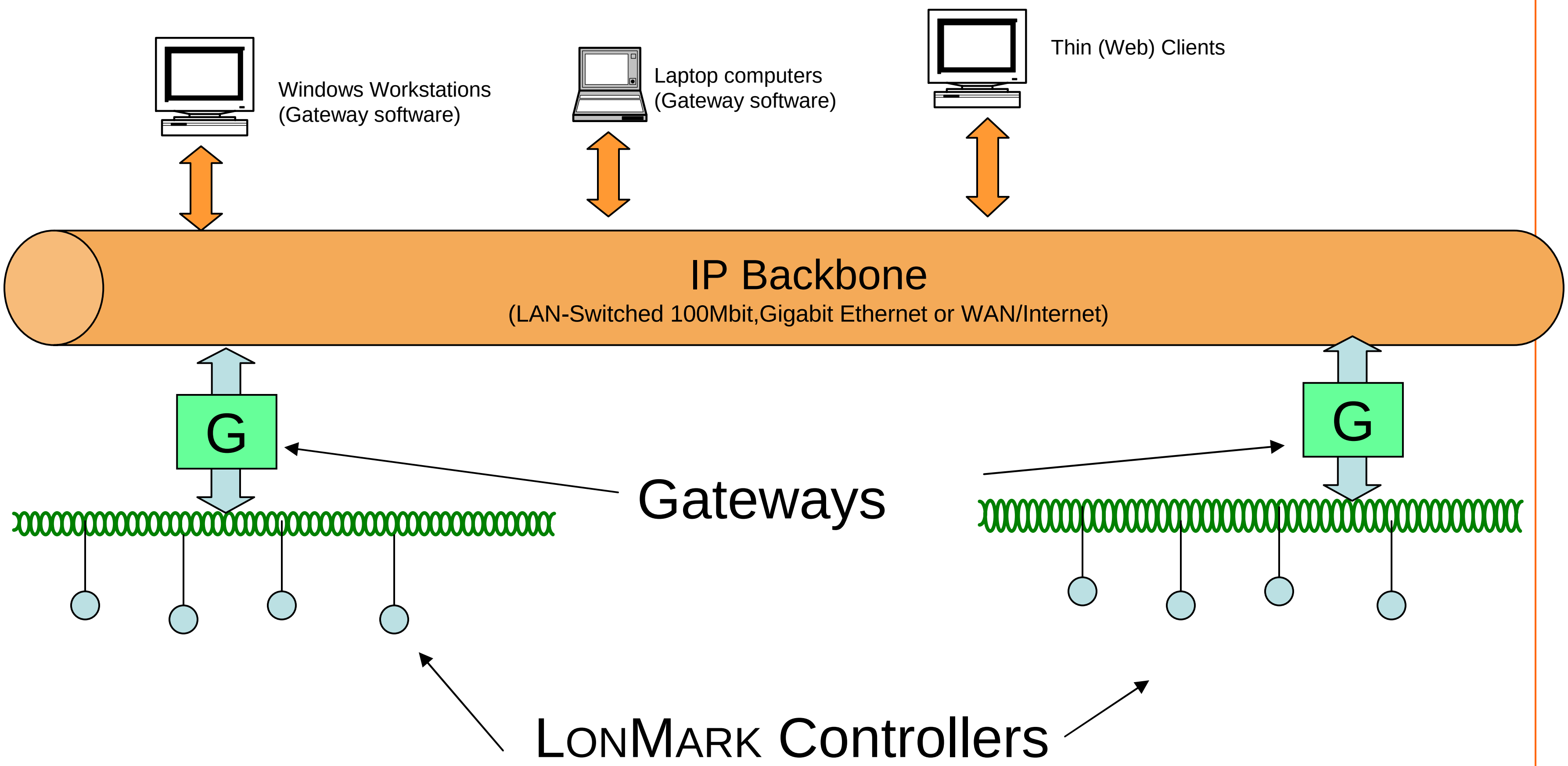
LONMARK 709.1 Network Routers



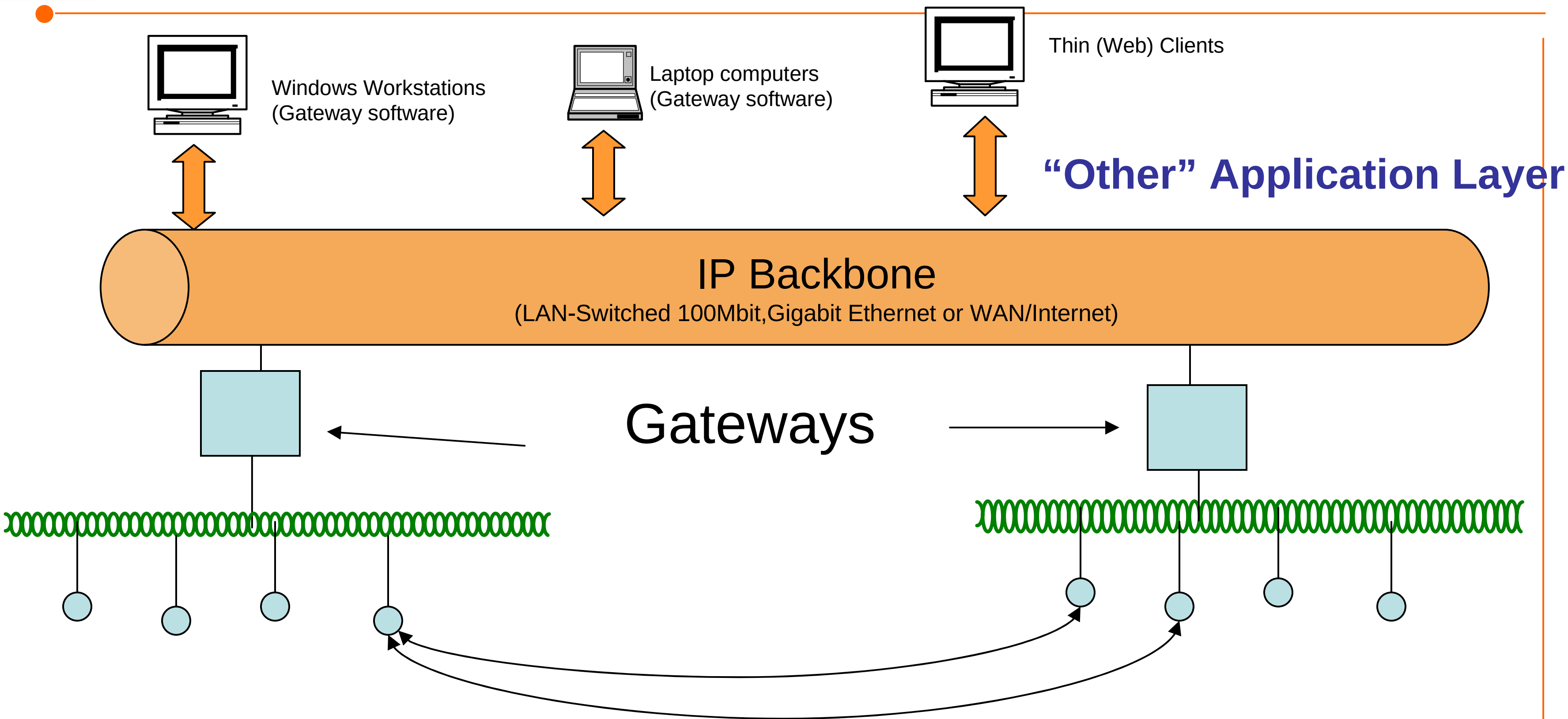
LONMARK System Plug-ins



Non 709.1 Network Routing

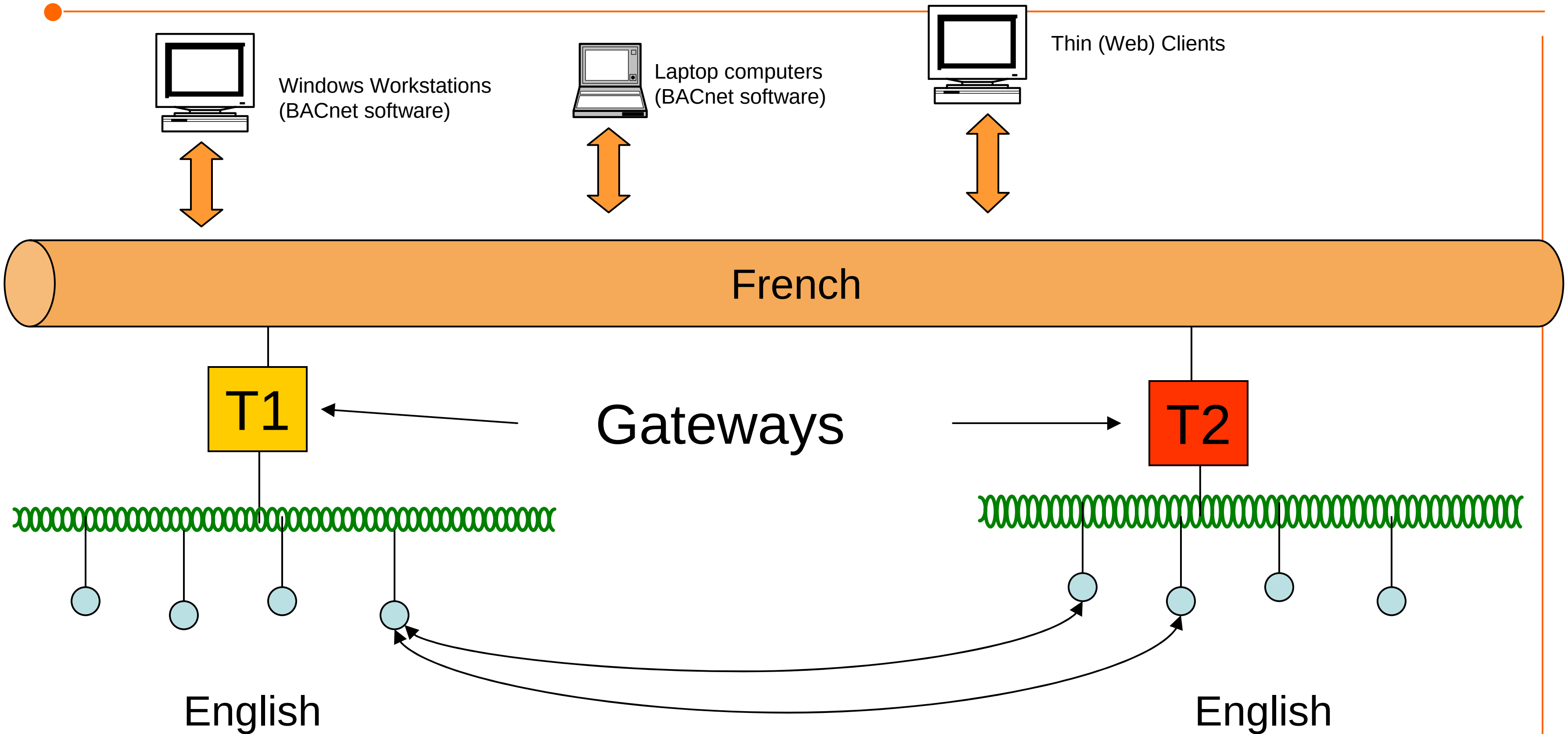


Non 709.1 Network Routing

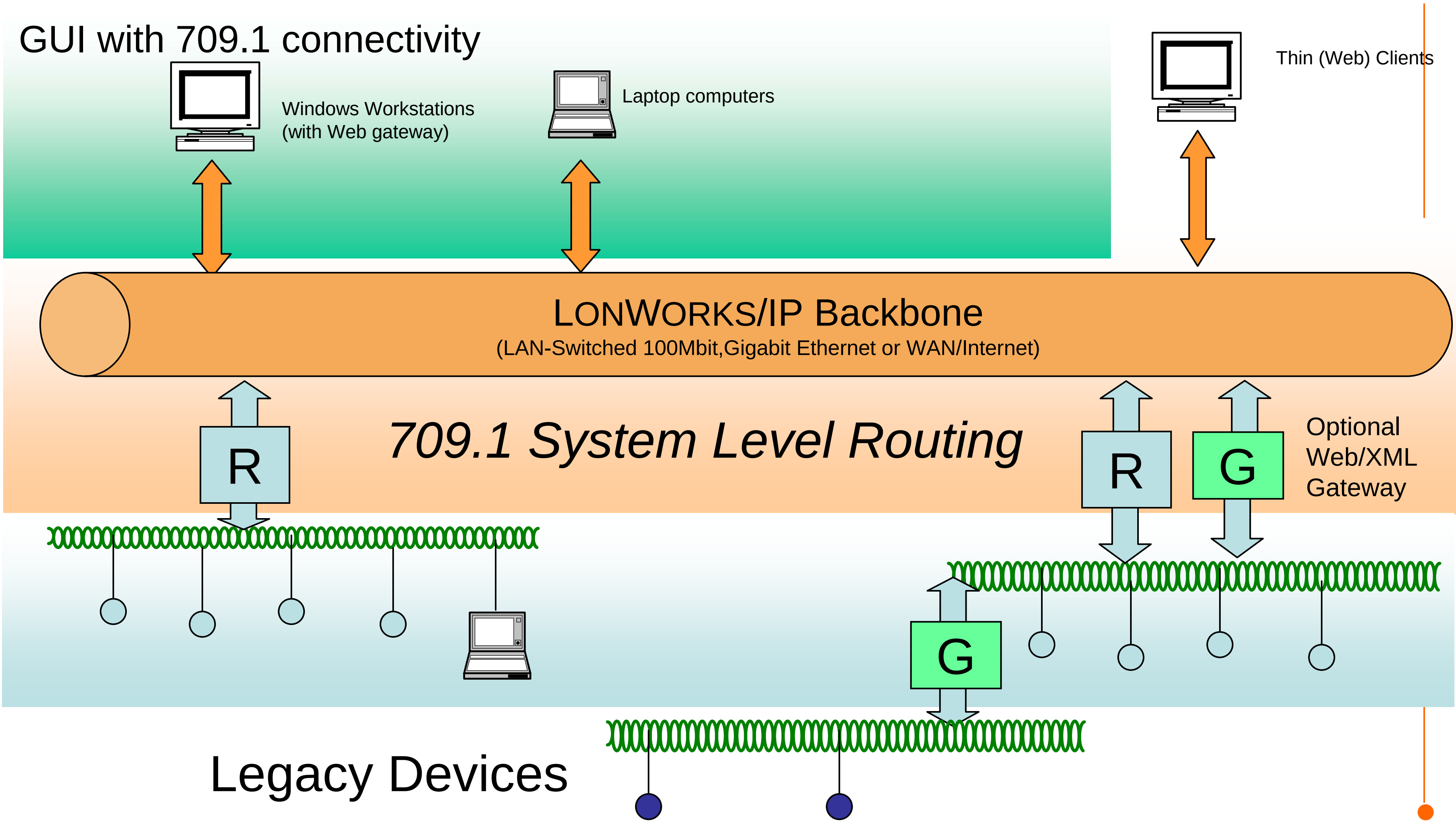


Gateways need to make a least two translations to share data

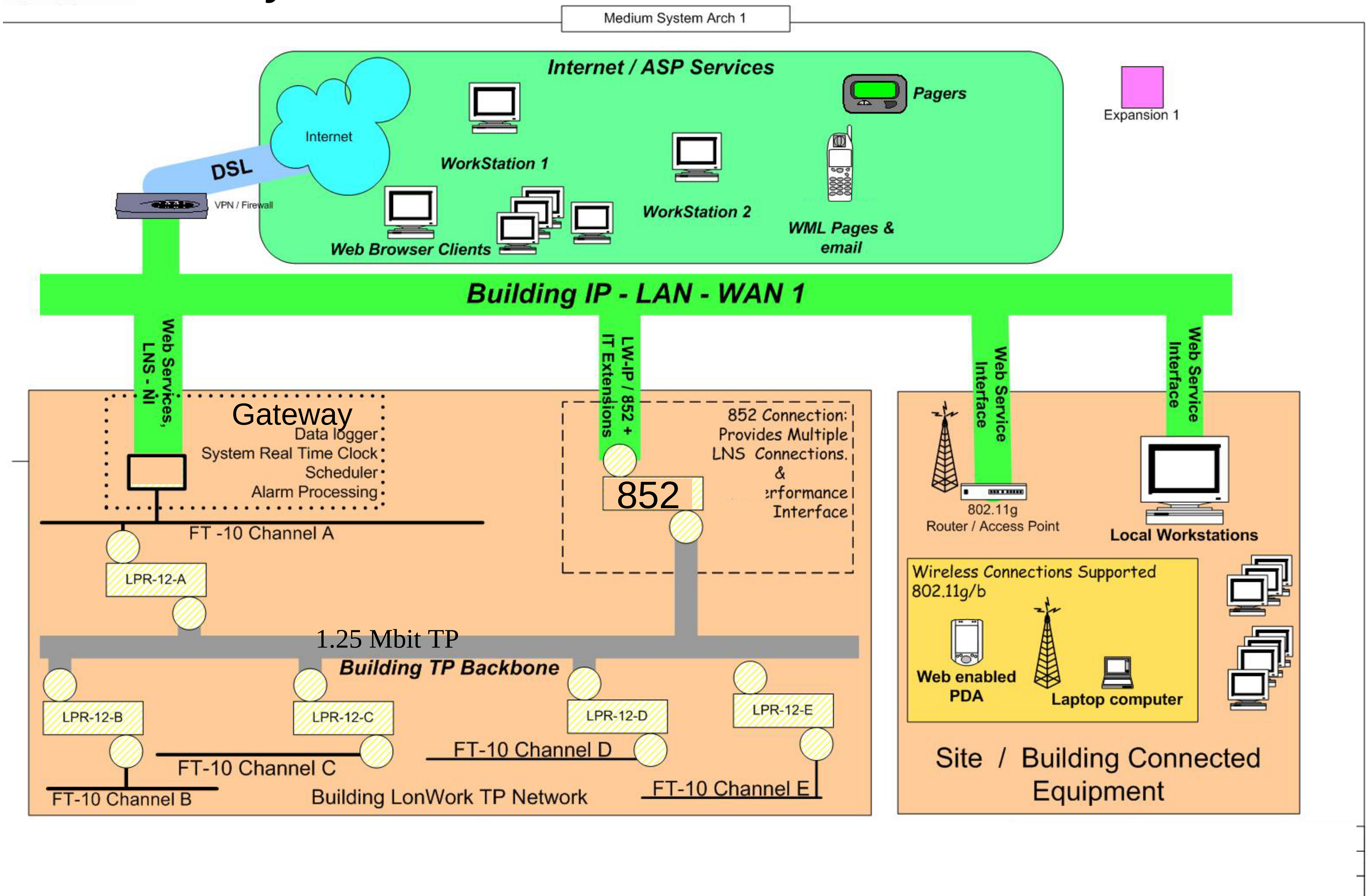
Non 709.1 Network Routing



709.1 Network Routing with Gateways



LONMARK Standards
A System Architecture Overview



XML – Extensible Markup Language

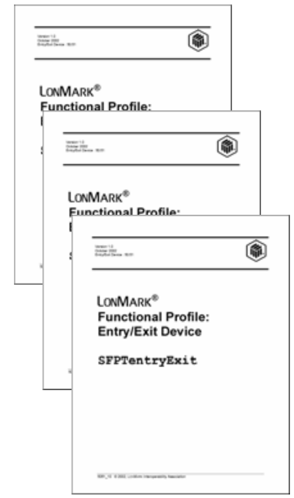
- eXtensible Markup Language (XML) is a meta-markup language that provides a format for describing structured data
- XML is largely thought of as a way to package data into a common format (or vocabulary) and pass those packages between heterogeneous systems
  - Platform independent way to represent data
- XML separates data, not just from program logic, but also from presentation
  - Content can be exported to web page, brochure, or enterprise applications
  - Allows web service applications to access data from other applications
- LONWORKS XML applications
  - Retrieve logged data from the network and populate SQL or Access database
  - Retrieve real time data for billing or ordering applications
  - Retrieve data for predictive maintenance applications

XML + LONMARK = Full Solution

XML:	LONMARK:
• Simple Web access – Via SOAP, etc.	• Full access to all devices' functions
• Enterprise integration	• Peer-to-peer integration
• Common XML interface for all datapoints	• Configuration and programming interface

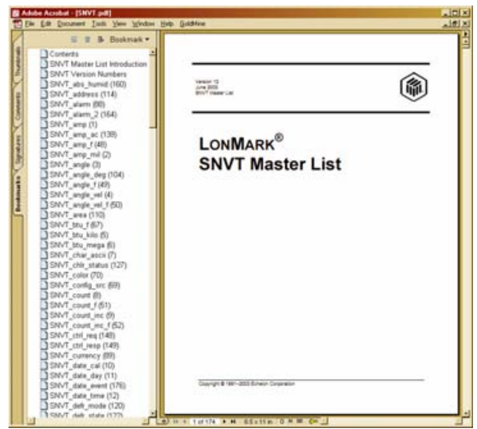
And LONMARK is Already There

Functional Profiles into XML



XML

SNVTs and SCPTs into XML



XML

and **XIF Files into XML**

(*coming soon*)

XML

LONWORKS Platform Products

- LONMARK Devices
  - Certified network controllers
  - Applications specific devices
  - Programmable devices
  - Scheduling, Alarming, Data logging
- Network Infrastructure
  - The wire the nodes connect to
  - The routers that pass the data
  - Termination
  - Traffic issues
  - Systems architecture
  - IT Routing
  - When are gateways necessary
- Tools
  - Design Tools
  - Commissioning Tools
  - Database issues
  - Plugins
  - Scheduling, Alarming, Data logging
- Host Interfaces
  - PC Based
  - Web Based
  - Flexibility and Choices
- Enterprise Connectivity
  - IT Interface
  - Large project architecture
  - Design for the future
  - Scalability issues

Getting Started

- Where do I go for help?
  - www.lonmark.org
  - www.lonmarkamericas.org
  - www.echelon.com
- Attend training classes
  - Classes are available for anyone on a variety of subjects
- Suggestions for a good Consulting Engineer?
  - Several very knowledgeable engineers are specializing in open systems
- More information?
  - CDs, Brochures, Success Stories, Data Sheets, White Papers
  - Just ask…
- Join the LONMARK organization

Thank You !

- Questions